AN ANALYSIS OF INDUSTRIAL ENGINEERING CURRICULA IN SELECTED SOUTHERN UNIVERSITIES

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CHAPTER I

INTRODUCTION

Western civilization today is a highly technological one which has resulted from rapid advances in scientific discovery and applications of those discoveries to purposes useful to mankind. The Industrial Revolution ushered in the modern industrial age with its complex problems in social, economic, and political affairs. The advent of the Atomic Age has complicated those problems. Concurrently, of course, the individual has been faced with many personal problems vastly different in scope and complexity, if not in magnitude, from those encountered by his forebears.

Need for the Study

Modern education should be so designed that the individual will be prepared as well as possible to face life and its problems both in the present and in the foreseeable future. The gravity of the situation is described by George S. Counts thusly:

> We are entering a new age in our history and the history of mankind. The grievous troubles of our time, the conquests of space, the advance of the machine, the fabulous power of our economy are for the most part but evidences of the release of mighty new forces that are transforming the very foundations of our existence.

> These new forces, science and technology, are carrying us swiftly either from one order of civilization to another or to our doom. Already, they have changed beyond recognition the material bases of our old way of life.[1]

The importance of education in this respect is stated in the Report of the President's Commission on Higher Education for American Democracy as follows:

> In a real sense the future of our civilization depends on the direction education takes, not just in the distant future, but in the days immediately ahead.[2]

Upon graduation from college, however, the average person is primarily concerned with his personal affairs, such as gaining a livelihood and getting married, rather than with problems of society, whether community, national, or international. To him the present is of greater concern than the indefinite future, and to the engineer in particular the technical aspects of his education assume greater importance in his mind than the nontechnical ones. The importance of the nontechnical education lies in the fact that it should help him to understand the problems of society in general, as well as his own specific problems, since they are tied closely together. Too often this part of education is not appreciated until later in life.

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[1] George S. Counts, "Education and the Crisis in Human Affairs," Committee on Social Foundations, (Ann Arbor: National Society of College Teachers of Education, January 1950), Chap. II, p. 5.

[2] Report of President's Commission on Higher Education, Higher Education for American Democracy, Vol. I: "Establishing the Goals," (Washington: U. S. Government Printing Office, 1947), p. 7.

From time to time, therefore, it is desirable that the college engineering curriculum be examined and analyzed in order to determine whether, in the light of our rapidly changing technological society, the current curriculum serves as an effective outline for the education of prospective engineers.

Statement of the Problem

Formal education should prepare a man to enter into the activities of the world in which he will live upon graduation from school or college. In addition, of course, formal education should lay the foundation for continuing personal development, a satisfying career, and adaptability to changing conditions in the future. These should be the goals, even though they are seldom achieved completely.

The problem selected for this study was to determine whether the curriculum of the industrial engineer provides suitable content and time to the various areas of study, to the end that he has been properly prepared not only for a professional career and satisfying life but also for his responsibilities and duties as a citizen. Good citizenship includes much more than voting, obeying the law, and knowing the history of the United States. It involves an understanding of a democratic society and the demands that it makes on its citizens in participating in the solutions of its ever-present problems by critical analysis, thought, and action.

The content of the college curriculum should provide basic knowledge and habits of thinking that will lead to the development of attitudes and values consistent with that society, including the handling of personal affairs. For this purpose the curriculum includes the art of communication, the humanities, social, and related studies. In the professional or technical field, the curriculum should include basic sciences, fundamental engineering theory, and special industrial engineering subjects necessary to prepare him for his chosen career.

The complete curriculum should provide not only a proper technical background but also the nontechnical education outlined above. The construction of such a curriculum has presented a difficult problem since the establishment of the earliest engineering schools, and the problem becomes more difficult as time goes on. The continuing advances in science and engineering demand more and more time for technical studies; on the other hand, the increasing complexities of modern living demands more time for education in nontechnical areas.

Definition of Terms

Science is a branch of study concerned with observations and classification of facts, especially with the establishment of verifiable general laws; accumulated knowledge systematized and formulated with reference to the discovery of general truths or the operation of general laws.

Engineering is the art of organizing and directing men and utilizing and controlling the forces and materials of nature for the use of mankind.

Industrial Engineering is concerned with the design, improvement and installation of integrated systems of men, materials, and equipment. It draws upon specialized knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems. It is one of the newest branches of the engineering profession.

General Education means nontechnical education which may be considered as common to all educated persons in areas not characteristic of any occupation or profession; for example, the humanities, social studies, and language arts.

Sources of Data and Procedure

In order to secure the information necessary for this study, opinions were sought and obtained from sources considered qualified to comment on the industrial engineering curriculum. These sources were employers of industrial engineers, and industrial engineering graduates of the

University of Florida. In addition, comparisons were made of the industrial engineering curricula of seven Southern institutions having accredited curricula in this branch of engineering.

The data used for evaluating the education of industrial engineers were obtained by the use of two different but similar questionnaires.[1] One was sent to companies and corporations which employ industrial engineers, insofar as could be ascertained. These companies, ranging in size from fifty to over 100,000 total employees, were located geographically throughout the country. Special attention was given to the selection of companies in diversified types of industry. There were also included various types of commercial activities such as transportation, communications, and public utilities.

The other style of questionnaire was sent to industrial engineering graduates of the University of Florida.

The data used for comparing the engineering curricula of various Southern universities and colleges were obtained from their current catalogs.

Limitations of the Study

As indicated by the title, this study of engineering curricula was limited to Industrial Engineering. However, the employers in their replies to the questionnaires referred generally to all engineers, except for those items which apply primarily to industrial engineers, since the basic science and engineering courses and general education studies are practically the same for all branches of engineering.

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[1] Appendixes A and B.

Much of the data obtained from the questionnaires, especially with respect to details of the curriculum, were necessarily matters of opinion and therefore to some degree qualitative in nature. Supplementary information such as type of industry was of course factual, as was the curricular data obtained from the catalogs of the various institutions whose curricula were compared. Because of practical limitations, only certain selected Southern institutions were included in the comparison of the curricula.

Related Studies

A considerable body of literature on engineering education and engineering curricula is in existence. This includes books, formal studies, informal articles in journals of engineering societies, and similar periodicals. Mentioned below are those studies which are considered most pertinent to this work.

In 1918 Charles R. Mann completed a report on engineering education.[1] It was initiated in 1907 by a Committee on Engineering Education composed of members of the societies of some of the principal branches of engineering and the Society for the Promotion of Engineering Education (now American Society for Engineering Education), and financially supported by the Carnegie Foundation for the Advancement of Teaching. The report was comprehensive in scope, describing conditions as they then existed, covering such topics as curricula, types of instruction, admission procedures, content of courses, and testing and grading. The author discussed the various problems involved in engineering education, and suggested solutions to such problems.

In 1938 Dugald C. Jackson prepared a report on the status and trends of engineering education, from data obtained by the Committee on Engineering Schools of the Engineers Council for Professional Development originally for use in accrediting engineering curricula in engineering schools of the United States.[2] His report summarized these data which were collected over a period of several years;

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[1] Charles R. Mann, "A Study of Engineering Education" The Carnegie Foundation for the Advancement of Teaching. Bulletin No. 11 (Boston: The Merrymount Press, 1918).

[2] Dugald C. Jackson, "Present Status and Trends of Engineering Education in the United States," Engineers Council for Professional Development, (New York: Engineers Council for Professional Development, n.d.)

it included charts showing distribution of credit hours in the fields of basic sciences, arts of expression, engineering plus technical and science electives, and humanistic and social sciences. These charts also showed the trends in civil, electrical, and mechanical curricula from 1893 to 1934.

In 1938 F. L. Eidman made a study of the evaluation by employers of recent young graduates of engineering schools.[1] Included in the study was a question as to the degree to which they were satisfactory, and what their faults were. The main faults listed pertained to personal traits and attitudes, the major deficiency being lack of ability to get along with associates.

A comparison of industrial engineering curricula was made by James M. Apple in 1947. This survey was based on courses included in industrial engineering curricula in the catalogs of twenty-five institutions offering accredited curricula.[2] Twenty-four courses were listed in the table included in the study; of these, seven were offered by 50 per cent or more of the colleges.

In early 1949 the Department of Industrial Engineering at Pennsylvania State College made a questionnaire survey of its graduates to determine what they were doing, and to obtain their evaluation of the Department's current curriculum. Similar questionnaires were also sent to 115 companies in industry. The curriculum was divided into four areas: basic engineering, industrial engineering, other engineering, and humanities. The results of this survey, which were summarized by George L. Thuering of the Industrial Engineering Department at the College, indicated that no changes were necessary in basic engineering, and that other engineering could be reduced or not changed. Industrial engineering and the humanities were listed either for expansion or no change.[1]

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[1] F. L. Eidman, "The Young Engineering Graduate in Industry," Journal of Engineering Education, Vol. XXVIII, No. 9 (1938), pp. 598-608.

[2] James M. Apple "Comparison of Industrial Engineering Curricula," Journal of Engineering Education, Vol. XXXVII, No. 10 (1946-47), pp. 821-24.

In 1955 a report prepared by William K. LeBold was published, giving the results of a survey made by a committee at Purdue University for the purpose of ascertaining the distribution of engineers among various job categories and of determining the attitudes of industrial leaders with regard to engineering curricula.[2] Information was solicited regarding engineering curricula in general, based on the division of engineers' employment into three categories of work: new developments; operations; and human relations. The detailed summary of the report among other things listed the percentages of engineers with doctor's, master's, and bachelor's degrees engaged in each of the three categories, also certain subjects which should receive more emphasis, among which were English, humanities, advanced science, engineering economics, psychology, and government.

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[1] George L. Thuering, "Forty Years of Industrial Engineering," Advanced Management, Vol. XIV, No. 4 (1949), pp. 17-19.

[2] William K. LeBold, "Industry Views the Engineering Graduate and His Curriculum," Journal of Engineering Education, Vol. XLV, No. 10 (1955), pp. 808-17.

In 1957 the General Electric Company published the results of a study of approximately 24,000 technical and nontechnical college graduates in its employ, in which the employees were asked to evaluate their college education in relation to their subsequent careers.[1] Nine questions were posed in the questionnaire, ranging from specific subject matter to manner of financing college expenses. The engineers ranked mathematics, English and engineering, in that order, highest on the list of subjects contributing most to their careers. Foreign language, history and engineering were ranked, in that order, of least value in the list of subjects making the minimum contribution to their careers. As the report states, extreme care must be taken in interpreting the replies.

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[1] What They Think of Their Higher Education (Schenectady: The General Electric Co., 1957).

General Outline of the Study

This study is divided into seven chapters as shown in the Table of Contents, and incorporates a pattern of presentation as outlined below.

After the introduction and statement of the problem, there is discussed the history of the development of engineering from the days of the early Egyptians, Greeks and Romans, through the Industrial Revolution to the present day. Particular emphasis is placed on the part that engineering and science have played in the evolution of Western Civilization, culminating in the present highly technological society and economy.

The next chapter describes the rise of engineering education from the empirical type to the formal higher education of today.

The remaining chapters contain analyses and evaluations of the basic data, together with findings, conclusions, and recommendations resulting therefrom.

CHAPTER II

ENGINEERING IN WESTERN CIVILIZATION

Civilization, according to Webster's Dictionary, is "a state of social culture characterized by relative progress in the arts, science, and statecraft." This chapter deals with the progress of engineering and its effects on civilization from the days of the ancient Egyptians, Greeks, and Romans to the present.

The history of man is the history of man's struggle to wrest food, shelter, and clothing from nature, and to protect himself from his enemies. Progress in achieving these basic requirements was slow, but it did not stop at the level of bare survival.

Engineering in its most elementary form began when man outgrew his nomadic existence and commenced to cultivate plants and settle in a chosen location, thus starting an agrarian society. A natural consequence was the rise of towns and cities, and new occupations such as tradesmen and artisans.[1] The latter class comprised those who constructed buildings, roads, bridges, water supplies, and irrigation systems, and of course, fashioned the tools and implements as required for their trades.

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[1] Richard S. Kirby et. al., Engineering in History (New York: McGraw-Hill Book Co., Inc., 1956), pp. 4-5.

Ancient and Medieval Engineering

Considering their comparative lack of scientific knowledge the ancient Egyptians, Greeks, and Romans performed some outstanding feats in construction. Some of the most widely known, of course, were the pyramids of Egypt, the Greek temples and Roman roads, bridges and aqueducts. These were the work of skilled craftsmen, or master builders. Their knowledge was empirical, that is based primarily on experiment and experience, combined with judgment and a sense of proportion.

The Greeks, in addition to their accomplishments in practical works, were also advanced in science, but the application of science to practical purposes was prevented by the class structure of Greek society, and the lack of mathematics except geometry and simple arithmetic. In the words of Finch:

> Science, in fact, became a natural philosophy and, as such, both completely divorced from engineering and incapable of further development.[1]

This pattern of separation between science and technology unfortunately lasted for many centuries. Science continued as a natural philosophy, an intellectual search for its own sake; meanwhile, the Greek engineer proceeded along his empirical route.

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[1] J. K. Finch, Engineering and Western Civilization (New York: McGraw-Hill Book Co., Inc., 1951), p. 15.

The Romans in the days of the Empire tended more toward practical matters, in contrast to the Greeks of comparable class status. It is evident that a high order of practical sense and judgment was required for the creation and maintenance of the Roman Empire.

The most commonly known Roman accomplishments were in the field of construction, such as buildings and temples, roads, bridges, and water systems with their aqueducts; in addition, there were supporting activities such as mining and metal working, and fabrication of necessary instruments, machines and equipment.[1,2]

After the decline of the Roman Empire, civilization entered a dormant intellectual period. As described by Cubberley, this was a period of preservation of previous knowledge; concurrently, in some respects there was a lowering of intellectual levels. Superstition was widespread, infiltrating both the field of science and the Church.[3]

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[1] R. J. Forbes, Man the Maker (New York: Henry Schuman, 1950), Chap. IV.

[2] Kirby et al., op. cit., Chap. IV.

[3] Ellwood P. Cubberley, The History of Education (Boston: Houghton Mifflin Co., 1920), p. 127.

During this period there were some advances in practical engineering such as improved methods of utilizing water, wind, and animals as power sources in place of manpower, and on the military side the development of fortified castles and the use of gunpowder. The latter led to metallurgical advances because of the exacting requirements for firearms and cannon.

In the field of construction the greatest advance was in the methods used in building the famous Gothic cathedrals. To quote Finch again:

> The cathedral plan may have evolved from that of the Roman basilica or even earlier temple constructions, but the men who, without the aid of stress analysis or modern structural knowledge, planned and erected these "bird cages in stone" were indeed worthy of the title master builders.[1]

Thus, it can be seen that for many centuries progress in engineering was a matter of slow evolution. Its main contributions were in the construction of buildings, and what are now called public works, such as roads, bridges, water systems, canals and harbors. These accomplishments were significant in the development of cities, commerce and trade, but the overall effect on the production of goods and the general standard of living was not great.

The Renaissance, which is the period covered generally by the fourteenth, fifteenth, and sixteenth centuries, saw the rise of a spirit of inquiry that had long been suppressed by the Church. The many factors which led to this development are described by Cubberley in some detail.[1] Some important results of this questioning attitude were the rise of Protestantism, new approaches to schools and education, and most pertinent to this study, great activity in scientific matters. The latter led to a re-examination of ancient science with its many fallacies and, in these and later centuries, to many new scientific discoveries which ultimately became the basic tools of the engineer.

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[1] Finch, op. cit., p. 24.

The Industrial Revolution

In antiquity, human beings were the primary source of power available to engineers. Eventually, over the centuries methods were devised to make use of animal, water, and wind power. However, power from these sources was limited both in extent and flexibility of application.

In the early eighteenth century crude steam engines were designed and built, but these were mainly used for pumping, since they were not yet developed to the point where reciprocating motion was converted to rotary motion as required for most industrial applications. This limitation was overcome when James Watt (1736-1819), in the last quarter of the eighteenth century developed a successful rotative steam engine. The Age of Steam, and the Industrial Revolution were launched, and mechanical and industrial inventions and developments proceeded at a rapid pace.

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[1] Cubberley, op. cit., Chaps. VIII and XII.

[2] Ibid., Chap. XVI.

In the following century, radical changes occurred in both the social and economic structures of society, especially in England. France was well advanced in the sciences and was the leading nation in the utilization of scientific ideas in practical engineering in many fields. However, for reasons too complex to be discussed here, England rather than France became the leading industrial nation.[1]

Heretofore engineering work was concerned mainly with buildings, roads, bridges, water supplies, and similar public works. Now, with mechanical power available technology joined with industry to make full use of the new source of power. One of the most important results was an accelerated growth of the existing factory system in industry. This development had far-reaching effects on the social and economic systems; production of goods was greatly increased and the consequent stimulation in commerce made necessary the development of improved transportation systems. Britain became an industrial nation--an exporter of manufactured goods and an importer of foodstuffs and raw materials--a pattern which has persisted to this day. The development of methods for producing steel in large quantities made possible advanced designs and construction techniques heretofore held back by the limitations of cast iron and wrought iron, particularly in the fields of factory equipment, railroads, bridges, and ships. In addition, steel became an important export.

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[1] Finch, op. cit., pp. 32-38.

American engineering development paralleled the British in many respects. However, there were two important differences. The settling of the western lands created a vast agricultural area, while industry remained concentrated in the east, mainly in New England, making for a more or less balanced economy, with a large domestic market. To obtain the benefits of this situation, good transportation was needed. To meet this need, roads and canals were built to supplement natural waterways. The advent of the railroad changed this picture by providing fast transportation over the long distances involved. With this emphasis on rail transportation, the construction of railroads and rolling stock became the major field of engineering in the United States.[1]

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[1] *Ibid.*, p. 68.

Modern Developments in Engineering

These rapid advances in technology and the consequent changes in our way of living were based on the utilization of steam power. The use of steam (and also water) as a direct source of power had one great disadvantage--it had to be used where it was generated. This disadvantage was overcome with the invention of practical means of generating electricity on a large scale near the end of the nineteenth century. This ushered in the Age of Electricity--exemplified by our modern electric power systems. Energy derived from prime sources of water and steam power could now be transmitted over great distances.

The phenomenal growth of this industry, in many ways, has had as great an influence on modern life as the introduction of steam power. It has extended the amenities of city living to rural areas, and has made possible not only the location of industries at considerable distances from the power source, but also more efficient industrial equipment and operating procedures. But this was only the beginning of the electrical age, for there soon followed the development of the field of electronics with all its ramifications in communications and industry.

This same period saw another revolutionary development--the internal combustion engine--which also has had an enormous effect on modern living. The automobile put the nation on wheels, resulting in such mobility of the population that many people have lost their roots as well as their local provincial attitudes. The airplane, long a dream, was made possible, and has brought all parts of the world closer together. Finally, much of this progress would have been impossible without the parallel development of the chemical industries.

The requirements of military engineering have contributed in many ways to technical progress, not only in ancient and medieval times, but continuously to the present. Military weapons and equipment demand the best over-all performance possible, always taking into account the ultimate function of the article. Where civilian designs and materials can be adapted and improved for military purposes, such improvements are made often without regard to cost, since the ultimate cost of losing a war because of inferior equipment would be vastly greater. However, many improvements resulting from military demands have been adapted later to civilian use, where applicable, at little or no cost, since the expense of development has already been paid by the government. Recent examples are radar, jet engines for aircraft and nuclear energy power plants.

It should be noted, however, that all these material gains have not been without cost in human suffering. Men, women, and children worked in the early factories and mines under what would now be considered appalling conditions until these conditions were changed by law. Laws designed to ameliorate conditions of labor are, in some form, in effect today.

Industrial Engineering

Early engineers, either lacking or unacquainted with basic scientific principles, had to depend on past experience, trial and error, or simply sense of proportion. For many years the factories operated in a similar manner. However, in the last years of the nineteenth century, Frederick W. Taylor (1856-1915) made a scientific study of the working methods used by both unskilled laborers and experienced machinists. He extended this study into higher levels of management and evolved certain principles which should be followed for efficient operation of a factory. These principles included gathering, tabulating, classifying, and reducing to usable rules and formulas all data regarding the work involved in a man's job, all as a duty of management. Included also were determination of best methods in doing the job, proper time allowances, pay according to performance, definite assignment of tasks, and scientific selection and training of the workmen. This procedure he called scientific management--which is the application of scientific principles to factory management.[1]

During the next quarter century Frank W. Gilbreth (1868-1924), with his wife Lillian Gilbreth as co-worker, developed time and motion study techniques. However, many people were working on other techniques to improve efficiency, increase production and decrease costs. One of the most important was the moving assembly line. Henry Ford (1863-1947), while not the originator of this idea, was the first to adopt it on a large complex scale. This procedure, together with the use of standardized and interchangeable parts, which was originated in the latter part of the eighteenth century, became the basis for mass production, and subsequently has been adopted by most industries where its techniques are applicable.

Mass production was an American contribution to industry which made great numbers of products available to the public at comparatively low cost. The results are all around us--from automobiles to airplanes, and canned goods to clothing.

The application of scientific principles to production and management became the basis of a new branch of engineering--Industrial Engineering. It differs from most other branches of engineering in that it is concerned primarily with the integration of men, methods, machines, and money into an efficient system of production of goods, whereas most other branches of engineering deal mainly with the design of the goods or articles themselves. Great emphasis is placed on both the human element and the economic aspect.

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[1] Frederick W. Taylor, Scientific Management (New York: Harper and Brothers, 1947), pp. 36-39. (Note: This work was first published in 1911.)

Industrial engineering, by name and origin, is involved primarily with manufacturing industries; however, many of the principles and practices are applicable in varying degrees to nonmanufacturing industries such as transportation, services and communications.

Summary

As civilization changed from a nomadic to an agrarian society there arose towns, cities, trade, and many new occupations. The artisan class constructed buildings, roads, and water supplies, and, of course, the tools and implements needed for both this type of work and for agriculture.

As this stage of civilization progressed the art and skill of the workmen progressed accordingly. Among the earliest examples of their creativeness and practical abilities are the well-known public works of early Greece and Rome. These skilled artisans were forerunners of our modern engineers, but their methods were mainly empirical, since there was little or no scientific background on which they could base their designs.

With the advent of the Industrial Revolution, which resulted mainly from the successful development of the steam engine, the factory system of production grew at an accelerated pace. New factories, in turn, created demands for factory equipment and better means of transportation on both land and sea in order to handle the increased production and trade. These developments led to many changes in our way of life, principally the change from an agrarian to an industrial economy and society, bringing in their wake many new social and economic problems. These changes and problems were greatly accelerated by later industrial inventions and developments such as the internal combustion engine and with it the airplane and automobile, the widespread use of electricity, and the rise of chemical industries.

In the early twentieth century, the idea of mass production by use of the moving assembly line was introduced into many industries with widespread effects on practically all aspects of our economy. This development brought into being the new branch of engineering known as industrial engineering, which is concerned mainly with industrial production, although many of its basic principles are applicable to nonmanufacturing activities.

CHAPTER III

ENGINEERING EDUCATION

In the history of Western civilization, formal education in applied science and engineering is of relatively modern origin, as compared to education in such basic sciences as chemistry, physics, and mathematics. For centuries these basic sciences were included in the field of natural philosophy and, except in France, there was little application of scientific discoveries to practical engineering until the second half of the nineteenth century.

Beginnings of Technical Education

The architects and engineers of ancient and medieval times were undoubtedly men with great talent and ingenuity as evidenced by their feats of construction. They had no formal education in the modern sense, although the formation of the medieval craftsmen's guilds did provide some organized education and training through the master-journeyman-apprentice relationship. The knowledge passed on by the master to the apprentice was based on past experience supplemented by the creative ability of the master to devise new designs and methods.

Beginning with the Renaissance period many important, basic scientific discoveries were made. Although these discoveries were widely known the influence of Greek thought still predominated; that is, the attitude that science was an intellectual pursuit and hence not to be considered for its utilitarian value.[1,2] Nevertheless in the eighteenth century steps were taken to provide organized instruction for engineers.

The lead was taken by France by the establishment, in 1747, of the Ecole des Ponts et Chaussees (School of Bridges and Highways). Later, the French Revolution brought forth a reorganization of the French educational system--still later extended by Napoleon--which included the foundations for higher technical education by the establishment of scientific and technical schools, including military schools.[3] For many years thereafter France was the leader in the applications of science to engineering practice.[4]

In the German States trade schools were established early in the nineteenth century; these developed later into

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[1] Finch, op. cit., pp. 14, 87.

[2] William J. Durant, The Story of Philosophy (New York: Simon and Schuster, Inc., 1926), p. 64.

[3] Cubberley, op. cit., pp. 517-18.

[4] Finch, op. cit., pp. 52-54.

technical schools. After the formation of the German Empire in 1871 these schools were given special attention and elevated to the rank of universities with emphasis on scientific research and the application of such research to industry. As a result of this policy, Germany became a leading industrial nation.[1]

In England engineering developments were based mainly on empirical practices, and formal engineering education received comparatively little attention until the last part of the nineteenth century. According to Curtis, this belated attention to the benefits of formal engineering education on scientific lines was forced by the realization by Britain that Germany, the United States, and other countries were challenging its industrial leadership as evidenced by the superiority of many of their products shown at the Great Exhibition in London in 1851 and the Paris exhibition of 1867.[2] The attitude in Britain toward applied science as described by Barnard was that the purpose of universities was to teach people to think and that practical applications of such thinking was not their business.[3]

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[1] Cubberley, op. cit., p. 797.

[2] Stanley J. Curtis, History of Education in Great Britain (London: University Tutorial Press, Ltd., 1950), pp. 482-83.

[3] Howard C. Barnard, A Short History of English Education from 1760 to 1944 (London: University of London Press, Ltd., 1947), p. 111.

It may be well to emphasize at this point the importance of applied science to engineering. First, with respect to the definition of science it will be noted that reference is made to verifiable general laws and operation of general laws. This means that, given certain scientific facts, results of the application of these facts can be predicted, within limits governed by the accuracy of the facts. This ability to predict is the essence of science, and is the basis of modern engineering designs which produce a balance of the desired factors of efficiency, safety, economy of materials, labor, and money. Empirical practices cannot produce a proper balance of those factors. The principle applies not only to the design of material things but also to methods, processes, and organization of people which are the primary concern of the industrial engineer.

Modern Engineering Education in the United States

The first engineering school in the United States was the United States Military Academy which was established at West Point, New York, in 1802 for the purpose of training military engineers. It was not until some years later that the curriculum and purpose were changed to provide for general military training. In 1824 the Rensselaer Polytechnic Institute was founded at Troy, New York, as a school of natural science, but in ten years it had evolved into an engineering school, primarily civil engineering.

Although there was a demand for more scientific information for the purpose of increasing production in both agriculture and manufacturing, the growth of educational institutions was slow, as described by Mann:

> For engineering education the striking features of this period from 1770 to 1830 are the gradual and persistent growth of the demand for scientific information for the purpose of increasing production, and the scanty attention given to devising ways and means of satisfying it.[1]
>
> At length in 1847, through private benefactions, the Lawrence Scientific School was established at Harvard and the Sheffield Scientific School at Yale. The University of Michigan also voted that year to offer a course in civil engineering.[2]

The next and extremely important step was the passage by the Congress of the Morrill Land Grant Act in 1862 which gave Federal aid to the States for the purpose of advancing learning in agriculture and in the mechanic arts, but including other areas of study. From this point on formal engineering education spread rapidly; engineering departments, divisions or schools were organized in existing state universities and colleges, and separate engineering institutions were established. Similar actions were taken in the field of independent, privately supported institutions. (In 1956 there were 808 engineering curricula spread among 153 institutions accredited by the Engineer's Council for Professional Development).[1]

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[1] Mann, op. cit., p. 4.

[2] Ibid., p. 5.

The function of the new engineering education, as described by Mann, was systematic instruction in applied science, with the ultimate aim that industrial production would be increased, and "engineering would become a learned profession and scientific research a recognized necessity."[2]

During this period which covered the last part of the nineteenth and the early part of the twentieth centuries, the majority of the engineers were self-taught men of unusual talent. However, as Jackson states, "this route became more difficult to traverse as the structure of science expanded, and, during the past century, formal engineering education grew into general acceptance."[3]

The early engineering schools were faced with many problems in setting up the various curricula. For instance, there was the question of content and time allotment for the main areas of study, which were general education (humanities, English, history), basic sciences, engineering sciences, and technical subjects (including shopwork). However, if increased production (in some nonmanufacturing industries, improved design) was the primary goal, then greatest emphasis was needed on scientific and technical subjects, including research.

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[1] _24th Annual Report of the Engineer's Council for Professional Development, for the Year Ending September 30, 1956_ (New York: Engineer's Council for Professional Development, 1956), p. 9.

[2] Mann, _op. cit._, p. 11.

[3] Jackson, _op. cit._, p. 9.

On the other hand, modern discoveries and research in science with their engineering applications have produced a complicated civilization with high standards of living as described briefly in the preceding chapter. It would appear then that since the engineer and his works occupy such an important place in our modern technological society, the education of the engineer should encompass many aspects of life besides those which are distinctly technical.

It may be taken for granted that the technical education of the engineer should properly prepare him to enter his chosen profession and to enable him to earn a livelihood with prospects of a successful career; it is also highly desirable that he derive some personal satisfaction from his work. However, he should also be aware of the fact that he is a member of society and that his work may entail social responsibilities as well as professional responsibilities.

This point of view is well stated in the following quotation from the Report of the President's Commission on Higher Education:

> All too often the benefits of education have been sought and used to personal and private profit, to the neglect of the public and social service. Yet individual freedom entails communal responsibility. The democratic way of life can endure only as private careers and social obligations are made to mesh, or personal ambition is reconciled with public responsibility.[1]

A later statement along similar lines is found in the Report of the Committee on Evaluation of Engineering Education as follows:

> The determination of the pattern which engineering education should take in the future must, of necessity, be based on the obligations of the engineering profession to society and upon the development of the student as an individual. The obligations of an engineer as a servant of society involve the continual maintenance and improvement of man's material environment, within economic bounds, and the substitution of labor saving devices for human effort. Moreover, his activity usually has a direct bearing on the welfare and safety of large segments of society.[2]

It is thus emphasized that the engineer in his work as a professional man has obligations to society; specifically, in many areas he has a responsibility for the safety of the public in his various creations from bridges and buildings to railroads and airplanes, and even in the household appliances in common use. As an individual there is the need to fulfil, to the extent possible, his own philosophy as to a satisfactory personal life. There arises the question of defining the objectives of engineering education. These are well stated in the report just mentioned, as follows:

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[1] Op. Cit., p. 10.

[2] Report of the Committee on Evaluation of Engineering Education, L. E. Grinter, Chairman (Lancaster: American Society for Engineering Education, June 1955), p. 4.

> The first objective, the technical goal of education, is preparation for functions of analysis and creative design, or of the functions of construction, production, or operation where a full knowledge of the analysis and design of the structure, machine, or process is essential.
>
> The second objective, the broad social goal of engineering education, includes the development of leadership, the inculcation of a deep sense of professional ethics, and the general education of the individual. These broad objectives include an understanding of the evolution of society, and of the impact of technology on it; an acquaintanceship with and appreciation of the heritage of other cultural fields; and the development of both a personal philosophy which will insure satisfaction in the pursuit of a productive life and a sense of moral and ethical values consistent with the career of a professional engineer.[1]

With respect to the first objective stated above it is obviously essential that a professional engineer should be technically proficient. With regard to the second objective it should not be expected that the engineer should be expert in all fields of human activity, any more than those engaged in the legal, medical, and other professions. The following quotation illustrates the difficulty in constructing an ideal curriculum:

> Some today would prefer engineers trained as psychologists, sociologists, economists,

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[1] Ibid., p. 5.

> politicians - each exclusively and each under the guise of adapting engineers to the world in which they live. Others suggest that young engineers be made into research specialists, experimenters, physicists. Still others urge that they should be given character and common sense and conservatism. Some seem to mistake the teacher for the Almighty.
>
> As a consequence, the curriculum is being pulled in different directions by followers of different philosophies. One group would emphasize research, another the creative elements, and others would include so much of the general knowledge of other disciplines as to leave little room for essential training.[1]

It is obvious, therefore, that much thought must be given to the curriculum in order to achieve the best possible balance between general and technical education. In the words of Weil:

> The responsibility of the engineering college is basically far greater than to train the young man for mere technical proficiency. It must give him a general education that will make him cognizant of the underlying factors which affect our modern sociological and industrial world.[2]

Moreover, the college can only lay the groundwork for the future. Burr stated in 1893, "that education, particularly professional education, creates nothing; that its functions are to draw out, to develop systematically and symmetrically those latent powers with which the individual is endowed, not in ripeness or maturity, but in condition only for growth."[1]

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[1] Hardy Cross, Engineers and Ivory Towers. Edited by R. C. Goodpasture (New York: McGraw-Hill Book Co., Inc., 1952), p. 32.

[2] Joseph Weil, "Building an Engineering Curriculum." Journal of Engineering Education, Vol. XLI, No. 10 (1951), p. 579.

Summary

Formal education in engineering is of comparatively modern origin. Prior to the nineteenth century most engineering works, however excellent, were the products of empirical design, based on trial and error and a good sense of proportion and symmetry.

Late in the eighteenth century some schools were established for the education of engineers, but mainly these were for military purposes. In general, until the latter part of the nineteenth century, with some exceptions, engineering design proceeded along empirical lines. Although many discoveries had been made in the basic physical sciences and mathematics in the preceding centuries, engineers, for a long time persisted in their empirical practices rather than in utilizing the scientific knowledge available. In part, this situation was caused by the rather widespread attitude that science was an intellectual activity as a part of natural philosophy, and should not be connected with utilitarian purposes. Although France was a leading nation in recognizing the utilitarian value of scientific discoveries,

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[1] William H. Burr, "The Ideal Engineering Education," Proceedings of the Society for the Promotion of Engineering Education, Vol. I, (July, 1893), p. 18.

Germany, starting in the late nineteenth century, became the leading nation in scientific research and its industrial applications, as witnessed by her rapid emergence as an industrial world power.

In the United States the importance of engineering education was given great impetus by the passage by the United States Congress of the Morrill Land Grant Act of 1862 which led to the establishment of many engineering schools, colleges, and institutions. However, the emphasis on technological education raised the question of the place of the engineer and his works in the structure of society. It is, of course, obvious that the education of the engineer should properly fit him for his professional work; however, it should also be broad enough that the engineer should obtain a sense of perspective as to the profound effect of scientific and engineering developments on society.

CHAPTER IV

EVALUATION OF INDUSTRIAL ENGINEERING CURRICULUM BY INDUSTRY

The preceding chapter noted some of the problems associated with setting up an engineering curriculum. From a purely technical viewpoint it was stated that the engineering graduate should be prepared to enter his profession with an adequate technical background. Since our modern economy and social organization have become extremely complex it is necessary that the curriculum also provide a general education at least adequate to provide the graduate with some understanding of our society and his place in it.

In order to obtain the views of industry in regard to the education of the industrial engineer a questionnaire[1] was sent to various companies widely diversified as to size, geographical location, and type of product or services. The selection of the companies was made from various sources, including business and industrial directories, technical periodicals, and job and placement directories; in addition, there were also included those firms listed as employers by engineering graduates to whom questionnaires were sent (see following chapter).

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[1] Appendix A.

Types of Industry

Questionnaires were mailed to 330 firms, from whom 180, or 55 per cent, usable replies were received. Table I shows the distribution of these firms by type of industry. The great majority of course were in the field of manufacturing, which accords with the original selection of the firms, since the majority of industrial engineers enter this industry.

TABLE 1

TYPES OF INDUSTRIES REPORTED
BY 180 EMPLOYERS

Types	Number	Per Cent
Manufacturing	168	94
Transportation	3	2
Public Utilities	1	--
Communications	2	1
Services	4	2
Marketing	--	--
Other	2	1
Totals	180	100

The remainder of this chapter analyzes the answers to the questionnaires by tabulation of the replies to the specific questions asked. The latter have been divided into two categories--those replies dealing with general education and those concerned with technical education.

It should be noted that most of the tables total less than 180, because in many cases one or more questions were not checked.

General Education

The present accumulation of engineering knowledge, together with continuing developments, indicate that greater time or emphasis should be given to professional studies. On the other hand, increasing complexities of present day living indicate a greater need for general education. This section shows the attitude of the respondent industrial firms toward various aspects of general education as reflected in the following tables.

The first question asked and the replies thereto are given in Table 2.

TABLE 2

RESPONSE OF 177 EMPLOYERS AS TO WHETHER MORE EMPHASIS SHOULD BE PLACED ON GENERAL EDUCATION AT THE EXPENSE OF PROFESSIONAL EDUCATION

Item	Number	Per Cent
Yes	75	42
No	77	44
Undecided	25	14
Totals	177	100

In some respects this was a difficult question to answer simply "Yes" or "No" without qualification. Six firms which checked "Yes" suggested a five-year curriculum; this suggestion was also made by six firms in the "No" and "Undecided" categories. The following statement of one of the latter may be considered pertinent:

> Need for general education is important, but not at expense of professional education. Probably 5 year course is answer--but--I doubt if many students would then take Industrial Engineering.

Although there are in existence many individually owned and operated businesses our modern, complex industrial economy is composed largely of organized companies and corporations which range in size from 25 to 75,000 or more employees. The efficient functioning of these organizations requires the co-ordination of many persons with specialized knowledge in many fields. Consequently the ability of people to get along with others in the organization has become of great importance. Tables 3 and 4 reflect the attitudes of industrial firms toward this ability.

TABLE 3

RESPONSE OF 177 EMPLOYERS AS TO THE DEGREE THEIR ENGINEERS SHOW ABILITY TO GET ALONG WITH PEOPLE

Item	Number	Per Cent
Good	90	51
Fair	84	47
Poor	3	2
Totals	177	100

TABLE 4

RESPONSE OF 180 EMPLOYERS AS TO WHETHER MORE EMPHASIS SHOULD BE PLACED ON THE ENGINEER'S ABILITY TO GET ALONG WITH PEOPLE

Item	Number	Per Cent
Yes	150	83
No	20	11
Undecided	10	6
Totals	180	100

As may be seen in Table 3, approximately one-half of the engineers in industry are rated good and one-half fair in this respect. Nevertheless, Table 4 indicates that more emphasis should be placed on the development of this ability.

Eleven firms not only checked "Yes" but also emphasized the point by writing in remarks on the subject. Three typical remarks are quoted:

> The human relations aspect cannot be overemphasized.
>
> In general we feel that any courses which would improve the ability of engineering graduates to get along with and get things done through people are worthwhile.
>
> Engineers have to be able to get along with rank and file. They have to sell their activities both to management and to operators.

There were discussed previously in Chapter III the responsibilities of the engineering profession to the well being of our society and economic system. Referring to Table 5, it appears that industry feels that engineers have a "Fair" to "Good" rating in this respect.

TABLE 5

RESPONSE OF 177 EMPLOYERS AS TO THE DEGREE THEIR ENGINEERS SHOW AN APPRECIATION OF THEIR RESPONSIBILITIES IN THE ECONOMIC SYSTEM

Item	Number	Per Cent
Good	62	35
Fair	105	59
Poor	10	6
Totals	177	100

The importance that industry attaches to general education in the overall education of the engineer is shown in Table 6.

TABLE 6

RESPONSE OF 179 EMPLOYERS AS TO THE IMPORTANCE OF GENERAL EDUCATION TO AN ENGINEER

Item	In his professional work		In understanding civil and political affairs	
	Number	Per Cent	Number	Per Cent
Essential	76	42	93	52
Desirable	100	56	79	44
No opinion	3	2	7	4
Total	179	100	179	100

It should be noted that in the engineers' professional work 56 per cent of the replies considered general education to be desirable and 42 per cent rated it essential. In understanding civil and political affairs the percentages were reversed--56 per cent rating it essential, and 44 per cent desirable.

The advancement of an engineer up the ladder of the organization generally is a measure of success in his chosen career. This measure of success however, depends on one's personal philosophy and may take several forms--personal satisfaction in his work, social position, financial rewards, or various combinations thereof. Advancement in industry usually includes a combination of the factors just mentioned. The part that general education plays in the advancement of engineers in industry according to the replies received is shown in Table 7.

TABLE 7

RESPONSE OF 178 EMPLOYERS AS TO WHETHER GENERAL EDUCATION AFFECTS THE ADVANCEMENT OF AN ENGINEER, ASSUMING REQUIRED PROFESSIONAL ABILITY

Item	Number	Per Cent
Greatly	53	30
Considerably	107	60
Slightly	18	10
Totals	178	100

As shown in this table it can be seen that in 90 per cent of the replies general education was rated as being of considerable to great importance in the advancement of the engineer in industry, provided, of course that he had the required professional competence.

Ability to Use the English Language

The ability to use one's native language (in this case English) properly and correctly is expected of any educated person. To a large degree this is expected of the high school graduate; certainly a college graduate should be proficient in this respect. It is not to be expected that the engineering graduate should be highly proficient in writing poetry or prose fiction; he should, however, be able to convey his ideas clearly, in both speech and writing, and he should be able to spell correctly. This is particularly true of the engineer wherein he deals primarily with fact, not fiction. The ability to read with speed and comprehension is also highly desirable, and in the higher echelons of management it is essential.

The opinions of industry in regard to the engineer's ability to use the English language, as given in the replies to the questionnaires, are shown in Table 8. In ordinary conversation the percentages were almost equal for good and fair. The ability to speak in small groups was checked as "Fair" in approximately two-thirds of the replies. Speaking to small groups such as conferences, is a frequent occurrence in most companies and is a highly desirable accomplishment.

In spelling, approximately one-half of the engineers were rated fair, with equal percentages of "Good" and "Poor." Regardless of the peculiarities of the English language, there would appear to be little excuse for one-quarter of engineering graduates to be unable to spell properly.

As mentioned above, the ability to read with speed and comprehension is not only highly desirable but, in some circumstances, essential. Only 6 per cent of the engineers were deficient in this respect.

The ability to write factual letters and reports is very important. As distinct from fiction, technical writing should be clear, concise, and where appropriate, persuasive or convincing. The following three quotations from replies are pertinent:

> Report writing and the ability to condense volumes of technical data to a few sentences are two of the most important items for an I.E. to learn. Unless the I.E. can get his ideas across and sold to top management all the technical training is for naught.
>
> We find that engineers from most southern schools have a very poor background in English, spelling, composition, and normal human relations in industry. Engineering ability generally O.K. tho many lack desire to do anything except engineering as such.

TABLE 8

RESPONSE OF EMPLOYERS AS TO THE ENGINEER'S TRAINING IN ENGLISH

Category	Evaluation						Totals
	Good		Fair		Poor		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Ordinary Conversation	84	47	88	50	6	3	178
Public Speaking (Small Groups)	20	11	115	65	42	24	177
Spelling	39	22	95	54	42	24	176
Reading (Speed and Comprehension)	65	37	101	57	10	6	176
Writing (Letters and Memoranda)	31	18	110	62	35	20	176
Report Writing	44	25	100	56	33	19	177

> The ability of self expression is one of the most vital and neglected phases of technical training. Progress without this ability is most difficult. English is essential.

Technical Education

This section deals with the evaluation of the technical preparation of engineering graduates. As shown by Table 9 the list of subjects in that table is the same as that in the questionnaire, and follows very closely the industrial engineering curriculum at the University of Florida.

Table 9 is divided into four categories: basic sciences, basic engineering subjects, industrial engineering subjects, and miscellaneous subjects. The basic sciences listed in the questionnaire were mathematics, chemistry, and physics. As can be seen, two-thirds of the replies indicated that the present time or emphasis given to these subjects was satisfactory, while 31 per cent recommended greater attention and only 2 per cent recommended less attention.

The basic engineering subjects listed in the questionnaire were:

Engineering Drawing
Descriptive Geometry
Principles of Electrical Engineering
Thermodynamics
Kinematics (Mechanisms)
Engineering Mechanics (Statics & Dynamics)

TABLE 9

RELATIVE TIME OR EMPHASIS THAT SHOULD BE GIVEN TO VARIOUS SUBJECTS, BASED ON THE EMPLOYERS' EVALUATION OF PRESENT ENGINEERING EMPLOYEES

Subjects	Evaluation						Totals
	More		Satisfactory		Less		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Basic Sciences	52	31	113	67	3	2	168
Basic Engineering Subjects	39	24	115	71	8	5	162
Industrial Engineering Subjects							
Engineering Economy	73	43	91	54	5	3	169
Human Engineering	93	55	74	43	4	2	171
Methods, Time & Motion Study	44	26	112	65	15	9	171
Production Control	39	23	123	72	10	5	172
Plant Location & Layout	35	21	116	68	19	11	170
Industrial Organization	53	30	100	58	21	12	174

TABLE 9--Continued

Subjects	Evaluation						Totals
	More		Satisfactory		Less		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Materials Handling	54	32	101	61	12	7	167
Specifications, Contracts, Ethics	50	30	103	62	13	8	166
Accident Prevention(Safety)	47	28	105	63	15	9	167
Job Analysis & Evaluation	46	27	105	61	20	12	171
Quality Control (Inc. Statistical)	64	38	97	58	7	4	168
Miscellaneous Subjects							
Economics	58	35	101	60	9	5	168
Accounting (Elementary & Cost)	61	36	97	57	11	7	169
Industrial Psychology	90	53	74	44	5	3	169
Industrial Surveys & Reports	58	35	96	57	13	8	167
Personnel Management	59	35	85	51	23	14	167
Industrial Relations	74	44	84	50	11	6	169

Strength of Materials
Manufacturing Operations and Processes

It can be seen that 71 per cent of the replies checked these items as being satisfactory, 24 per cent thought that more attention should be given, and only 5 per cent indicated that less attention should be given to these subjects.

It may be pointed out here that all the above basic science and basic engineering subjects, except kinematics, are included in the curricula of the seven institutions whose curricula are compared later in Chapter VI.

All industrial engineering subjects listed, except human engineering, are also found in the curricula comparison in Chapter VI. It is considered, therefore, that the lists are fairly typical, although several other courses are listed in one or more of the institutions listed in Chapter VI. In addition there are many variations in course titles and descriptions found in the catalogs. In Chapter VI these will be discussed at greater length.

As noted in Table 9, 50 per cent or more of the replies indicated that the time or emphasis given to these subjects was satisfactory, except for the subject of human engineering where 55 per cent of the replies indicated that more attention should be given to this subject. Further discussion of this item will be found below under industrial psychology.

The last part of Table 9 lists miscellaneous subjects which, with certain exceptions, are generally required for industrial engineers, although they may be taught in departments or schools other than engineering, depending on the academic organization of the institution.

Again it will be noted that 50 per cent or more of the replies showed that the time or emphasis was satisfactory except for the one subject of industrial psychology. In the questionnaire, it was not practicable to give an overall, detailed description of this title although it is used in various forms to cover areas of applied psychology such as interviewing and testing applicants for jobs in industry, motivation of employees, working conditions, morale, accidents, and related topics. One book using this title is "Industrial Psychology" by Joseph Tiffin.[1] Similarly, it was not practical to give a detailed description of human engineering. As presented in the University of Florida, the course in human engineering considers the human factors involved in the operation of industrial equipment, processes and products so that in their design, care will be taken to see that the capabilities of the human operator are properly utilized but not exceeded; also included in this course is a study of human reactions to plant situations. The term human engineering is frequently used in the sense of applied psychology in industry, which may account for the percentages obtained for the above two subjects.

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[1] Joseph Tiffin, Industrial Psychology (2d ed. rev.; New York: Prentice-Hall, Inc., 1947).

Miscellaneous Remarks by Respondents

Seventy respondents, or 39 per cent, added remarks in the space provided in the questionnaire. These remarks in general emphasized or amplified the check lists. In addition to those referred to in connection with Tables 2, 4, and 8, the remarks recommended more emphasis on humanities, basic science, and basic engineering. The recommendations that more attention should be paid to basic principles were based on the premise that principles are relatively unchanging whereas specific applications of those principles are subject to rapidly changing technology.

The writer believes that there is a discernible relation among the replies shown in Tables 3 and 4, and those under human engineering, industrial psychology, and industrial relations in Table 9. These replies taken together circumscribe a definite area that the industrial engineering curriculum should emphasize, not only the ability to get along with people but also the methods of attaining objectives through proper handling of people.

(Another area of study that stands out is the one concerned with the vital problems of money--profit and loss. The three subjects listed which are most directly concerned with this aspect are engineering economy, economics and accounting.

More attention to these subjects was indicated in more than one-third of the replies, and less than 10 per cent thought that less emphasis should be given to them. Although the percentages for each subject may not be impressive, a pattern appears when the three subjects are taken collectively.

In the writer's opinion the validity of the replies received from the employers of industrial engineers was enhanced by the fact that the letter which accompanied the questionnaire displayed no evident connection between the writer and any organization--business, educational, or otherwise (except that he was working on a doctoral dissertation). In addition, twenty replies, or 11 per cent, were returned with a personal covering letter, although the questionnaire was made up to obviate this need, and accompanied by a self-addressed, stamped envelope. Further, the recipients were assured that the replies would be kept confidential, or could be returned unsigned. Another indication of validity is the interest shown in the survey as evidenced by the fact that 57 per cent of the respondents requested a summary of the results.

Summary

In summary, it was seen that employers of engineers recognize the importance of general education to an engineer both in his professional work and in his understanding of civil and political affairs; in addition, general education has considerable to great effect on his advancement in the company. It appears also that there is room for improvement in the engineers' ability to use the English language, and remedial action is indicated in this field of education.

In the technical field of study, 50 per cent or more of the replies showed that the time or emphasis given to technical courses was satisfactory, with the exception of the two courses discussed above. However, there was a discernible trend among the replies toward greater emphasis on the ability to get along with people not only as a matter of good human relations, but also in attaining desired objectives by working with and through people by good leadership.

A reasonable inference could also be made that employers attached considerable importance to the attention given in the industrial engineering curriculum to the financial aspects of industry.

CHAPTER V

EVALUATION OF INDUSTRIAL ENGINEERING CURRICULUM BY GRADUATES

This chapter analyzes the reactions of graduates of the University of Florida to the industrial engineering curricula in effect at that institution (with the exception of a few courses explained later) as set forth in the questionnaires sent to them.[1] This questionnaire was sent to 175 graduates whose mailing addresses were considered to be reliable; replies were received from 94 (55 per cent) of these persons.

The graduates who replied were dispersed geographically throughout this country, plus two in Canada and one in Puerto Rico. Because of this widespread distribution, and probable contacts with graduates from other institutions, it is considered that the replies gave fairly representative results.

The tables in this chapter, except for Tables 11 and 12, follow the order in which the questions appear in the questionnaire.

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[1] Appendix B.

Year of Graduation, Age, and Business Experience

Tables 10, 11, and 12 contain personal data regarding the graduates who replied. These are in general self-explanatory. However, it will be seen in Table 10 that 92 per cent of the graduates were in a range or spread of twelve years in dates of graduation, namely 1946 to 1957 inclusive.

TABLE 10

YEAR OF GRADUATION OF 94 INDUSTRIAL ENGINEERING GRADUATES OF THE UNIVERSITY OF FLORIDA

Year Group	Number	Per Cent
1935-40	5	5
1941-45	3	3
1946-50	20	21
1951-55	55	59
1956-57	11	12
Total	94	100

Table 11 shows the age of the graduates. Here 80 per cent fell within a twelve-year range from twenty-five to thirty-six years of age.

In business experience 92.0 per cent were in a twelve-year range from zero to twelve years, as shown in Table 12. It was not specified whether this included experience gained prior to graduation.

TABLE 11

AGES OF 94 INDUSTRIAL ENGINEERING GRADUATES OF THE UNIVERSITY OF FLORIDA

Age Group	Number	Per Cent
20-24	6	6.5
25-28	27	29.0
29-32	29	31.0
33-36	19	20.0
37-40	5	5.0
Over 40	6	6.5
Age not given	2	2.0
Total	94	100.0

TABLE 12

BUSINESS EXPERIENCE, IN YEARS, OF 94 INDUSTRIAL ENGINEERING GRADUATES OF THE UNIVERSITY OF FLORIDA

Year Groups	Number	Per Cent
0 - 2	31	33.0
3 - 5	23	24.5
6 - 8	24	26.0
9 - 12	8	8.5
13 - 16	3	3.0
17 - 20	4	4.0
Over 20	1	1.0
Totals	94	100.0

The above three tables show that the questionnaires were returned by a comparatively young group in both age and experience. There was the question of reliability of mail addresses because the longer the time since graduation the less likelihood there was of obtaining correct addresses, particularly in the case of those individuals outside the State of Florida. Possibly of equal importance was the likelihood that the older graduates would hesitate to express opinions on specific subjects of the curriculum because of the greater lapse of time since graduation, or because of the influence of their own particular experiences.

As may be expected, the majority were engaged in manufacturing industries, as shown in Table 13.

TABLE 13

TYPES OF INDUSTRIES IN WHICH 94 INDUSTRIAL ENGINEERING GRADUATES OF THE UNIVERSITY OF FLORIDA HAVE BEEN ENGAGED

Type	Number
Manufacturing	64
Transportation	4
Public Utilities	11
Distribution/Marketing	10
Communications	5
Government	19[a]
Other	21
	134

[a] Includes: Air Force 5; Army 2; Navy 3.

The total in this table exceeds the number of replies, because many of the persons have engaged in more than one type of industry.

Table 14 shows the specific type of work within any given industry in which the graduates have engaged.

TABLE 14

TYPES OF WORK IN WHICH THE INDUSTRIAL ENGINEERING GRADUATES OF THE UNIVERSITY OF FLORIDA HAVE BEEN ENGAGED

Types	Number
Technical	
Production	35
Methods Analysis	19
Sales Engineering	16
Maintenance/Repair	8
Design	20
Consulting Services	10
Other	24[a]
Administrative	
Supervision	35
Management	17
Personnel	7
Other	7[b]

[a] Includes: wage incentives (2); cost analysis (3); planning 6; safety (4); statistical (2).

[b] Includes: planning (3).

Although it may be inferred from Chapter III that industrial engineers are concerned primarily with production activities, it should be noted that a large number were engaged in sales engineering and design work in the technical field, and in supervision and management in the administrative area of business. Once more, however, the totals are not equal to the number of replies for the reason given above.

Basic Science and Basic Engineering Subjects

Table 15 shows the opinions of the graduates in regard to the relative importance of the basic science and engineering subjects.

More than two-thirds thought that the time given to the basic sciences was satisfactory. Only 6 per cent indicated that more time should be given to chemistry, but a much larger percentage thought that more time should be given to physics and mathematics, namely 30 per cent and 23 per cent respectively. Not one person suggested less emphasis on mathematics.

More than two-thirds of the replies also indicated that the emphasis placed on basic engineering subjects was satisfactory, except for three courses. These courses were electrical engineering, manufacturing operations and processes, and laboratory and shop experience, where 55, 32, and 40 per cent, respectively, were satisfactory. A comparatively high percentage of replies indicated that more time should be given to those subjects.

Industrial Engineering and Miscellaneous Subjects

There are listed in Table 16 the required industrial engineering subjects, except operations research, which are

TABLE 15

UNIVERSITY OF FLORIDA INDUSTRIAL ENGINEERING GRADUATES' OPINIONS OF THE RELATIVE TIME OR EMPHASIS THAT SHOULD BE GIVEN TO BASIC SCIENCE AND ENGINEERING SUBJECTS

Subjects	Evaluation						Totals
	More		Satisfactory		Less		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Basic Sciences							
Mathematics	28	30	65	70	-	-	93
Chemistry	6	6	76	82	11	12	93
Physics	21	23	70	75	2	2	93
Laboratory (Chemistry, Physics)	12	13	69	74	12	13	93
Basic Engineering Subjects							
Engineering Drawing	16	17	72	78	5	5	93
Descriptive Geometry	6	6	77	84	9	10	92
Principles of Electrical Engineering	35	38	51	55	7	7	93
Thermodynamics	11	12	64	69	18	19	93
Kinematics (Mechanisms)	15	17	65	71	11	12	91
Engineering Mechanics	20	21	62	67	11	12	93
Strength of Materials	21	23	62	67	9	10	92
Manufacturing Operations & Processes	60	65	30	32	3	3	93
Laboratory & Shop Experience	50	54	37	40	6	6	93

TABLE 16

UNIVERSITY OF FLORIDA INDUSTRIAL ENGINEERING GRADUATES' OPINIONS OF THE RELATIVE TIME OR EMPHASIS THAT SHOULD BE GIVEN TO INDUSTRIAL ENGINEERING AND MISCELLANEOUS TECHNICAL SUBJECTS

	Evaluation						
	More		Satisfactory		Less		Totals
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Industrial Engineering Subjects							
Engineering Economy	40	43	51	54	3	3	94
Human Engineering	34	36	50	54	9	10	93
Methods, Time & Motion Study	29	31	59	63	6	6	94
Production Planning & Control	53	57	38	40	3	3	94
Plant Location and Layout	26	28	58	62	10	10	94
Materials Handling	44	47	44	47	5	6	93
Operations Research	43	47	44	47	5	6	92
Industrial Organization	31	33	54	57	9	10	94
Specifications, Contracts, Ethics	18	20	64	69	10	11	92
Accident Prevention (Safety)	13	14	70	75	11	11	94
Job Analysis & Evaluation	8	8	71	76	15	16	94
Quality Control	47	50	41	44	6	6	94
Miscellaneous Technical Subjects							
Economics	17	18	68	73	8	9	93
Accounting (Elementary & Cost)	24	25	60	64	10	11	94
Industrial Psychology	29	31	54	58	10	11	93
Industrial Surveys & Reports	30	32	55	58	9	10	94
Personnel Management	33	35	54	57	7	8	94
Industrial Relations	31	33	57	61	6	6	94

given either as separate courses or as inclusions in other listed courses. Operations research is a comparatively new field of study. Although not offered as a course of study at the University of Florida, many aspects of its techniques are applicable to the solution of industrial engineering problems. It was listed in the questionnaire for the purpose of ascertaining the degree of interest in it among industrial engineers. According to the replies there was considerable interest in the subject.

Excluding operations research more than 50 per cent of the replies indicated that the time given to industrial engineering subjects was satisfactory, except for production planning and control, materials handling, and quality control. More than 40 per cent thought that more time should be given to those subjects and also to engineering economy.

Under miscellaneous are listed two required subjects--economics and accounting--and four subjects which may be of interest to industrial engineers and are frequently taken as technical electives.

General Education Subjects

The opinions of the graduates in regard to the emphasis on general education is shown in Table 17 (in which military and physical education were included for convenience).

TABLE 17

UNIVERSITY OF FLORIDA INDUSTRIAL ENGINEERING GRADUATES' OPINIONS OF THE RELATIVE TIME OR EMPHASIS THAT SHOULD BE GIVEN TO GENERAL EDUCATION

Subjects	Evaluation						Totals
	More		Satisfactory		Less		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
English	59	63	35	37	-	-	94
Social Studies (History, Gov't., etc.)	15	16	70	74	9	10	94
Humanities (Philosophy, Art, Lit., etc.)	19	20	57	61	18	19	94
Psychology (General)	26	28	59	63	8	9	93
Foreign Languages	7	8	50	56	32	36	89
Military Education	2	2	56	65	29	33	87
Physical Education	10	11	67	74	14	15	91

It is important to note that 63 per cent thought that English should be given more attention and that not one person recommended less emphasis. These results should be compared with the findings in Table 8 in Chapter IV in which 73 per cent of the employers indicated that engineers rated "Fair" to "Poor" in English. It is apparent, therefore, that most of the engineering graduates and employers agreed that there was room for improvement in the field of English, and that it should receive more attention.

The remainder of the subjects in this table were checked as satisfactory, the percentages ranging from 56 to 74. However, it should be noted that 36 per cent and 33 per cent felt that less time should be given to foreign languages and military education, respectively. As a matter of fact foreign languages are not required, but military education is required of all male students, with certain exceptions.

In connection with the preceding table, there is shown in Table 18 the value that the graduates attach to general education in the various aspects of everyday life. Only two items were evaluated at more than 50 per cent in the three value categories listed. Under the item "In the work in which you are engaged," 52 per cent thought that general education was of some value, while 44 per cent felt that it was of great value. By comparison with Table 6 in

TABLE 18

UNIVERSITY OF FLORIDA INDUSTRIAL ENGINEERING GRADUATES' OPINIONS OF THE VALUE OF THEIR GENERAL EDUCATION

Item	Evaluation						Totals
	Great		Some		Little		
	No.	Per Cent	No.	Per Cent	No.	Per Cent	
In the work in which you are engaged	40	44	48	52	4	4	92
In understanding the relation of the work of the engineer to our present economic system	36	42	42	48	9	10	87
In understanding the effect of continuing technological advances (such as automation) on our social and economic system	36	39	45	49	11	12	92
In understanding civic and political affairs--local, national, and international	54	59	34	37	4	4	92
In relation to your own personal and family affairs and problems	39	42	41	45	12	13	92
Satisfying use of leisure time	35	38	42	45	16	17	93

Chapter IV it will be seen that, in considering the importance of general education to an engineer, 56 per cent of the employers indicated that it was "Desirable," and 42 per cent "Essential."

The item "Understanding civic and political affairs" was evaluated by 59 per cent as being of "Great value," and by 37 per cent as of "Some value." By comparison, 52 per cent of the employers rated this item "Essential," and 44 per cent rated it "Desirable" as shown by Table 6.

In any educational institution the importance of good teachers is recognized. A good teacher should not only teach and help the student to learn, but he should also be able to inspire in the student interests beyond the scope of the course and the confines of the classroom. On the other hand, in certain courses which are tool subjects primarily of utilitarian value, the student may obtain a firm grasp of a subject from a good teacher whose only claim to the student's memory would be his ability to teach a given subject.

Consequently, there arises the well-known question as to the relative importance of subject matter versus influence of the teacher. Table 19 shows that, in engineering courses, 51 per cent of the students felt that the subject matter of the course was of greater value than the influence and personality of the teacher, and 31 per cent

TABLE 19

UNIVERSITY OF FLORIDA INDUSTRIAL ENGINEERING GRADUATES' OPINIONS OF THE EDUCATIONAL FACTORS "TEACHER INFLUENCE" VERSUS "SUBJECT MATTER," AS TO GREATEST VALUE

Item	No.	Per Cent
Engineering Courses		
Teacher Influence (Personality, etc.)	29	31
Subject Matter of the Course	48	51
Undecided	17	18
Totals	94	100
Nonengineering Courses		
Teacher Influence (Personality, etc.)	35	37
Subject Matter of the Course	26	28
Undecided	33	35
Totals	94	100

rated personality of the teacher first, with 18 per cent undecided. On the other hand in nonengineering courses, teacher influence was rated of greater value by 37 per cent, as against 28 per cent for subject matter, with 35 per cent undecided.

It is interesting to compare the above mentioned results with those obtained in the General Electric Company's survey wherein 48.84 per cent of the engineering graduates rated subject matter first, 45.28 per cent rated teaching personality first, and 5.87 per cent were undecided. In this survey, however, there was no separation into the categories of engineering and nonengineering courses.[1]

Summary

The majority of the graduates who replied to the questionnaire were in a comparatively young group covering a twelve-year range as follows: 92 per cent were graduated from 1946 to 1957 inclusive; 80 per cent were from 25 to 36 years of age; and 92.0 per cent had from less than one year to 12 years of business experience. The majority of the engineers were engaged in technical work in manufacturing industries, although many other types of work were listed.

With some exceptions most of the graduates considered that the time of emphasis given to the various courses of study was satisfactory. Of the basic engineering subjects, 50 per cent or more indicated that the courses in manufacturing operations and processes, and laboratory and shop experience should be given more attention.

It was considered that the emphasis given to the industrial engineering courses was satisfactory to more than 50 per cent of the graduates except for the courses in production planning and control, materials handling, and quality control; these courses were recommended for more emphasis by 57 per cent, 47 per cent, and 50 per cent, respectively.

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[1] General Electric Company, op. cit., p. 10.

It was pointed out in Chapter IV that employers placed considerable emphasis on human relations and the financial side of industry. A similar pattern of emphasis does not appear in the replies of the graduates. Only two individual subjects in those areas--human engineering and engineering economy--were checked for more emphasis in more than one-third of the replies. It is believed that a reasonable explanation for this situation lies in the fact that most of the replies were received from individuals with not over twelve years of business experience, and consequently they were concerned more with specific technical problems than with broad problems of management.

The general education received was considered satisfactory by most of the graduates, except in English; this subject was checked for more attention in 63 per cent of the replies.

Considering the question as to whether subject matter or teacher influence was most important in later life it was found that most of the graduates thought that the subject matter of the course was more important in engineering subjects, while teacher influence was more important in nonengineering courses.

CHAPTER VI

COMPARISON OF INDUSTRIAL ENGINEERING CURRICULA OF SEVEN SOUTHERN INSTITUTIONS

This chapter analyzes and compares the accredited industrial engineering curricula of the University of Florida and six other Southern institutions. The two preceding chapters reflected the viewpoints of engineering graduates and employers of engineering graduates on the adequacy of the education of industrial engineers, based mainly on the curriculum in effect at the University of Florida. As explained previously the University of Florida curriculum was used because the individuals to whom questionnaires were sent were all graduates of that institution.

The analyses and comparisons in this chapter are based on the industrial engineering curricula of the institutions listed below, according to their respective catalogs of the years indicated:

University of Alabama	(Ala)[a]	1956-58
University of Florida	(Fla)	1957-58
Georgia Institute of Technology	(Ga)	1957-58
Louisiana State University	(LSU)	1957-59
North Carolina State College	(NCS)	1956-58
University of Tennessee	(Tenn)	1957-58
Agricultural and Mechanical College of Texas	(Texas)	1956-57

[a] Abbreviations shown in this column are used in the tables.

It must be pointed out that the comparisons of courses were not exact for many reasons, the main ones being variations in course titles, and vague or indefinite descriptions of the courses. Also, in many instances different subject matters were combined in one course; in these cases the credits were apportioned by estimate among specific subjects. Although the resulting lack of exactness applies particularly to the courses in general education, it is also applicable in varying degrees to many of the technical courses.

Two institutions, the Georgia Institute of Technology and the University of Tennessee, operate on the quarter system in determining course credit hours, while the others are on the semester system. Semester hours were used in the tables in this chapter, the quarter hours of the two above institutions having been converted to semester hours in the ratio of three quarter hours equalling two semester hours.

This chapter contains six tables, each of which compares different aspects of the curriculum; where applicable, each table shows not only the credit hours for the various courses but also the range from minimum to maximum.

General Education Subjects

Table 20, under the heading of general education, contains English, the humanities and social studies, and

TABLE 20

GENERAL EDUCATION SUBJECTS INCLUDED IN THE INDUSTRIAL ENGINEERING CURRICULA OF THE SEVEN SOUTHERN INSTITUTIONS UNDER STUDY

Subjects	SEMESTER CREDIT HOURS							
	Ala	Ga	LSU	NCS	Tenn	Texas	Fla	RANGE
ENGLISH								
Writing	6	6	3	6	6	6	3	
Reading	3		4	9	6	2	3	
Speaking	2	2				1	2	
Sub-Totals	11	8	7	15	12	9	8	7 - 15
HUMANITIES AND SOCIAL STUDIES								
Literature, Art,) Philosophy, Music)	3	6	12	6	8		8	
Modern World	3			6				
Contemporary Am. Soc.		6					8	
Government						3		
History						6		
Economics	6	4			4	3	6	
Psychology (General)				3				
Electives			15	12			6	
Sub-Totals	12	16	27	27	12	12	28	12 - 28
TOTALS	23	24	34	42	24	21	36	21 - 42

miscellaneous nontechnical electives. It will be noted that the time spent on English in its entirety ranged from 7 to 15 hours, with 7 for Louisiana State University and 15 for North Carolina State College. The division of the time among reading, writing and speaking where not specified was estimated from the catalog descriptions.

Under humanities and social studies there are listed as humanities the generally accepted subjects of literature, philosophy, art, and music and as social studies such subjects as contemporary civilization, history, government and psychology. Unspecified nontechnical electives are also included in this table. The credit given for these subjects ranges from 12 hours for the Universities of Alabama and Tennessee, and the Agricultural and Mechanical College of Texas, to 28 hours for the University of Florida.

The total hours allotted to general education range from 21 hours for the Agricultural and Mechanical College of Texas to 42 hours for North Carolina State College. The courses in English, economics, psychology, and history listed in the table were considered as coming under the heading of general education, and should not be confused with technical studies with the same name which were included in a later table of technical subjects.

Basic Science and Engineering Subjects

The time allotted to the basic sciences of mathematics, chemistry and physics, and to basic engineering subjects or sciences is shown in Table 21. Here it will be seen that the total credit hours for the basic sciences varied from 32 to 42 with the minimum variation in chemistry.

Under basic engineering subjects there was considerable variation in the time allowed, even in the seven subjects which were common to the curricula of all the institutions listed. These subjects were:

Engineering Drawing
Descriptive Geometry
Engineering Mechanics
Thermodynamics
Electrical Engineering
Strength of Materials
Manufacturing Operations and Processes

Only two of the remaining subjects--fluid mechanics and metallurgy--were required in more than one-half of the curricula listed.

The credit hours for this part of Table 21 varied from 24 for North Carolina State College to 50 for Louisiana State College, while the total credit hours in this table range from 59 to 88 for the same two colleges, respectively.

TABLE 21

BASIC SCIENCE AND ENGINEERING SUBJECTS INCLUDED IN THE INDUSTRIAL ENGINEERING CURRICULA OF THE SEVEN SOUTHERN INSTITUTIONS UNDER STUDY

Subjects	SEMESTER CREDIT HOURS							
	Ala	Ga	LSU	NCS	Tenn	Texas	Fla	RANGE
			BASIC SCIENCES					
Mathematics	17	22	19	17	20	15	16	15 - 22
Chemistry	8	8	9	8	8	8	8	8 - 9
Physics	10	12	10	10	8	10	8	8 - 12
Sub-Totals	35	42	38	35	36	33	32	32 - 42
			BASIC ENGINEERING SUBJECTS					
Engineering Drawing	4	2 2/3	2	2	5 1/3	2	3	2 - 5 1/3
Descriptive Geometry	2	1 1/3	4	2	2 2/3	2	3	1 1/3 - 4
Kinematics (Mechanisms)	2					1	3	0 - 3
Engineering Mechanics	6	2 2/3	6	4	6	6	6	2 2/3 - 6
Thermodynamics	3	4	6	3	4	4	3	3 - 6
Electrical Engineering	4	4	8	4	6	8	8	4 - 8
Strength of Materials	3	4	5	2	2	4	3	2 - 5
Fluid Mechanics	3	2 2/3	4	2				0 - 4
Machine Design	2	3 1/3	8					0 - 8
Mfg. Operations & Processes	4	2	3	5	1 1/3	6	6	1 1/3 - 6
Metallurgy	3	2	4		2	3		0 - 4
Civil Eng. (Industrial Structures)	3							0 - 3
Engineering Analysis	4							0 - 4
Engineering Problems					1 1/3	3		0 - 3
Elementary Surveying					1 1/3			0 - 1 1/3
Chemical Engineering					4			0 - 4
Sub-Totals	43	28 2/3	50	24	36	39	35	24 - 50
TOTALS	78	70 2/3	88	59	72	72	67	59 - 88

Industrial Engineering and Nonengineering Technical Subjects

The remainder of the curriculum, listed in Table 22, was composed of two categories of subjects: those usually considered as strictly industrial engineering and taught in the engineering college or department, and others of a technical but nonengineering nature which may be taught in another college or department; an example of the latter would be accounting. However, as noted previously the specific departmental arrangement of course offering depends on the academic organization of the institution.

The total credit hours in this table varied from 20 for Louisiana State University to 52 for the Agricultural and Mechanical College of Texas.

The low number of 20 credit hours shown here for Louisiana State University was compensated for in great part by the high number (88 credit hours) found in Table 21. At this university industrial engineering is an option in mechanical engineering. This arrangement would account for the disparity, because of the greater amount of time shown for subjects which are usually emphasized in mechanical engineering.

It is desired to point out again the inexactness of these comparisons, because of the variations in course titles and descriptions, and combinations of two or more

TABLE 22

INDUSTRIAL ENGINEERING AND NONENGINEERING TECHNICAL SUBJECTS INCLUDED IN THE INDUSTRIAL ENGINEERING CURRICULA OF THE SEVEN SOUTHERN INSTITUTIONS UNDER STUDY

Subjects	SEMESTER CREDIT HOURS							
	Ala	Ga	LSU	NCS	Tenn	Texas	Fla	RANGE
Introduction to (Indust.) Eng.				1	2	2	2	0 - 2
Job Evaluation & Wages		2		3	2	3	2	0 - 3
Methods, Time & Motion Study	5	3 1/3		4	4	3	3	0 - 5
Engineering Economy		2	2	2	2		3	0 - 3
Plant Selection and Layout	3	2 2/3		3	4 2/3	3	3	0 -4 2/3
Plant Operation		2			1 1/3		2	0 - 2
Materials Handling		2		1	2		1	0 - 2
Production Control	3	2		3	2	2	1	0 - 3
Tool Engineering						3		0 - 3
Specifications, Contracts, Ethics		2			2	3	2	0 - 3
Safety Engineering		2	3		2/3		1	0 - 3
Industrial Org. & Mngmt.	3		3	3				0 - 3
Industrial Surveys & Reports		1 1/3						0 - 1 1/3
Human Engineering							2	0 - 2
Industrial Psychology		2						0 - 2
Industrial Relations						3		0 - 3
Industrial Economics	2				2			0 - 2
Elementary Accounting	3	2		3	4	3	6	0 - 6
Cost Accounting	3	2 2/3			2	3	3	0 - 3
Cost Estimating		2						0 - 2
Quality Control		2		3	4		1	0 - 4
Statistical Quality Control						3		0 - 3
Statistics	2	2		2	2			0 - 2

TABLE 22--Continued

Subjects	SEMESTER CREDIT HOURS							
	Ala	Ga	LSU	NCS	Tenn	Texas	Fla	RANGE
Technical English	2	2		3		3		0 - 3
Seminar	1	1 1/3		2	2	1	1	0 - 1 1/3
Thesis					2			0 - 2
Electives (Technical)	16	12	12	6	6	17	6	6 - 17
TOTALS	43	49 1/3	20	39	46 2/3	52	39	20 - 52

of the listed subjects into one course. Moreover, this picture could be altered considerably, depending on the selection of technical electives for which each institution made allowance, covering a range from 6 to 17 hours.

No course was common to the seven curricula listed in the preceding table; however, there is given in Table 23 below those courses which appear in more than half of them.

TABLE 23

COURSES COMMON TO MORE THAN ONE-HALF OF THE INDUSTRIAL ENGINEERING CURRICULA OF THE SEVEN SOUTHERN INSTITUTIONS UNDER STUDY

Course	Frequency
Plant Selection and Layout	6
Production Control	6
Elementary Accounting	6
Seminar	6
Job Evaluation and Wages	5
Methods Time and Motion Study	5
Engineering Economy	5
Cost Accounting	5
Introduction to Engineering	4
Materials Handling	4
Specifications, Contracts, Ethics	4
Safety Engineering	4
Statistics	4
Technical English	4

Military and Physical Education

All seven institutions required military education for two years (except for certain categories of students), but as may be seen in Table 24, there was considerable variation in credit allowed for this activity. This same table shows the credit allowed for physical education, which was not required in two institutions--the University of Alabama and Louisiana State University. In two of the remaining five, credit was not given, although the course was required; these institutions were the Agricultural and Mechanical College of Texas and the University of Florida.

In order to round out the general picture of the various curricula, Table 25 was compiled to show the time allotted to the principal areas of general education, fundamentals of science and engineering, courses specific to industrial engineering, and military and physical education.

The Report on Evaluation of Engineering Education and the Report on General Education in Engineering both recommend that approximately 20 per cent of the student's time be spent on general education.[1,2] Table 25 shows that the time given to general education ranges from 14 per cent for the Agricultural and Mechanical College of Texas to 27 per cent for North Carolina State College. In basic science and engineering, Louisiana State University is highest with

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[1] *Op. cit.*, p. 17.

[2] *Report of the Committee on General Education in Engineering*, E. S. Burdell, Chairman (Lancaster: American Society for Engineering Education, April, 1950).

TABLE 24

MILITARY AND PHYSICAL EDUCATION SUBJECTS INCLUDED IN THE INDUSTRIAL ENGINEERING CURRICULA OF THE SEVEN SOUTHERN INSTITUTIONS UNDER STUDY

Subjects	SEMESTER CREDIT HOURS							
	Ala	Ga	LSU	NCS	Tenn	Texas	Fla	RANGE
Military Education	4	8	8	8	4	4	4	4 - 8
Physical Education	-	4	-	4	1 1/3	0	0	0 - 4
TOTALS	4	12	8	12	5 1/3	4	4	4 - 12

TABLE 25

DISTRIBUTION OF TIME IN SEMESTER HOURS, BY BASIC CATEGORIES INCLUDED IN THE INDUSTRIAL ENGINEERING CURRICULA OF THE SEVEN SOUTHERN INSTITUTIONS UNDER STUDY

Institutions	CATEGORIES									
	General Education		Basic Sci. & Eng.		Industrial Engineering		Military & Phys. Educ.		TOTALS	
	Hrs	Per Cent	Hrs	Per Cent	Hrs	Per Cent	Hrs	Per Cent	Hr	%
Alabama	23	16	78	53	43	29	4	2	148	100
Georgia	24	15	70 2/3	45	49 1/3	32	12	8	156	100
Louisiana	34	23	88	59	20	13	8	5	150	100
N. Carolina	42	27	59	39	39	26	12	8	152	100
Tennessee	24	16	72	49	46 2/3	32	5 1/3	3	148	100
A & M Texas	21	14	72	48	52	35	4	3	149	100
Florida	36	25	67	46	39	27	4	2	146	100
Averages	29	19	73	49	41	27	7	5	150	100

59 per cent and North Carolina College is lowest with 39 per cent; by contrast, Louisiana State University is lowest in industrial engineering subjects with 13 per cent, and the Agricultural and Mechanical College of Texas is highest with 35 per cent.

It appears desirable here to point out that this study is to a considerable degree qualitative, although the results are given in the tables in quantitative form. Chapters IV and V are tabulations of opinions, and the tables in this chapter are based on course descriptions which were not exact or consistent among the various institutions being compared. However, there is in Table 25 one area in which the credit hours are quantitatively important, and that is the field of military and physical education. Referring again to Table 24, it will be seen that military education was credited with from 4 to 8 semester hours. According to the military authorities at the University of Florida the basic Reserve Officers Training Corps (ROTC) curriculum in actual clock hours (classroom and field drill), in general, is standardized throughout the country in land grant institutions, although the academic credits allowed are a prerogative of the institution concerned.[1]

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[1] Private communication from Colonel M. A. Kreidberg, U. S. Army Professor of Military Science and Tactics, University of Florida.

The influence of this credit can be seen by subtracting the military (ROTC) credits from the four-year total credit hours required for graduation.

This situation was discussed as a matter of some concern in the two reports just mentioned, in that it is usually the humanities and social studies that are reduced in credit hours if excessive credits are allowed for the military courses.[1,2] It should be clearly understood that these reports do not make objection to military training; they say in effect, that military training should not be substituted for regular academic work in either general or technical education.

Summary

The curricula of seven institutions in the South were compared in some detail. The curricula were divided into the following categories: general education, basic science and engineering, industrial engineering, and military and physical education.

Under general education there was considered English, humanities, and social studies. Basic science included mathematics, chemistry, and physics, and basic engineering

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[1] Report of the Committee on Evaluation of Engineering Education, Op. cit., pp. 678-79.

[2] Report of the Committee on General Education in Engineering, op. cit., pp. 26-27.

included such subjects as mechanics, thermodynamics, electricity, and engineering drawing and geometry, among others.

The comparisons were not subject to exact quantitative analysis because of variations in course titles and course descriptions, and the large number of elective courses allowed. Consequently the comparisons must be considered in a qualitative as well as quantitative light; nevertheless the data given in this chapter should be considered as informative within the limitations outlined.

In general education North Carolina State College led with 42 semester hours, with Agricultural and Mechanical College of Texas being low with 21 hours.

In basic science and engineering Louisiana State University had the highest total of 88 hours, as compared with North Carolina State College with 59 hours.

In industrial engineering and related technical subjects Louisiana State University was low with 20 semester hours, and Agricultural and Mechanical College of Texas was high with 52 hours.

In military education, three institutions, Georgia Institute of Technology, Louisiana State University, and North Carolina State College allowed 8 semester hours of credit while the other four allowed only 4 credit hours. Physical education was not required at the University of Alabama or Louisiana State University; in the other five institutions where it was required, the credit allowed varied from 0 to 4 hours.

It will be noted that the total semester hours for the four-year course varies from 146 to 156. If the credits for military and physical education are subtracted, the totals range from 140 to 145 hours. From an educational point of view the latter figures should be more comparable.

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

This study was initiated for the purpose of determining, within practical limitations, the fitness of the college or university education of engineers, with specific reference to industrial engineers. The last two centuries have seen great progress in technology especially in the twentieth century. The Industrial Revolution ushered in the modern industrial age with its complex problems in social, economic, and political affairs. The advent of the Atomic Age has complicated those problems still further. Concurrently, of course, the individual has been faced with many personal problems vastly different in scope and detail, if not in magnitude from those encountered by his forebears. Since the engineering profession has been largely responsible for this progress and its profound effects on our economy and society, it was considered that the education of the engineer was worth investigation.

The problem selected for this study was to determine whether the curriculum of the industrial engineer provides suitable content and time to the various areas of study, to the end that he has been properly prepared not only for a professional career and a satisfactory life, but also for his responsibilities and duties as a citizen.

Good citizenship includes much more than voting, obeying the law, and knowing the history of the United States. It involves an understanding of a democratic society and the demands that it makes on its citizens in participating in the solutions of its ever-present problems by critical analysis, thought, and action. The content of the college curriculum should provide basic knowledge and habits of thinking that will lead to the development of attitudes and values consistent with that society, including the handling of personal affairs. For this purpose the curriculum includes the art of communication, the humanities, social and related studies. In the professional or technical field, the curriculum should include basic sciences, fundamental engineering theory, and special industrial engineering subjects necessary to prepare him for his chosen career.

The complete curriculum should provide not only a proper technical background but also the nontechnical education outlined above. The construction of such a curriculum has presented a difficult problem since the establishment of the earliest engineering schools. The problem becomes more difficult as time goes on. The continuing advances in science and engineering demand more and more time for technical studies; on the other hand, the increasing complexities of modern living demand more time for education in nontechnical areas.

In order to secure the information necessary for this study, opinions were sought and obtained, by means of questionnaires, from sources qualified to comment on the industrial engineering curriculum. These sources were employers of industrial engineers, and industrial engineering graduates of the University of Florida. In addition, comparisons were made of the industrial engineering curricula of seven Southern institutions having accredited curricula in this branch of engineering.

The investigation was centered mainly around three categories of engineering education, namely: (1) general education, that is, the humanities (including English) and social studies; (2) basic sciences and basic engineering subjects; and (3) industrial engineering and related technical subjects.

The approaches made to this study were as follows: (1) the opinions of employers of engineers in regard to their (the engineers') education; (2) the opinions of the engineering graduates themselves as to the adequacy of their education; and (3) a comparison of the curricula of seven educational institutions in the South, in the light of the comments given by (1) and (2) above.

Evaluation by Employers

In Chapter IV an analysis was made of the replies to the questionnaire sent to 330 employers of industrial engineers. From the tabulation of 180 replies which were received, the following principal findings were obtained:

1. In types of industry 93 per cent were manufacturing.
2. Although 51 per cent reported that engineers had good ability to get along with people, 83 per cent recommended that more emphasis should be given to the development of this ability.
3. The degree to which engineers appreciate their responsibilities in our economic system was rated good by 35 per cent of the employers, fair by 59 per cent, and poor by 6 per cent.
4. The importance of general education to the engineer in his professional work was rated as being essential by 42 per cent, and desirable by 56 per cent; in understanding civil and political affairs general education was held to be essential by 52 per cent and desirable by 44 per cent.
5. Assuming the necessary professional ability, general education had great effect on the advancement of the engineer in the company in 30 per cent of the cases and considerable effect in 60 per cent.
6. In considering the engineers' training in English (reading, writing, spelling, speaking) 27 per cent were rated good, 57 per cent fair, and 16 per cent poor.
7. In technical education, 50 per cent or more of the employers considered that the time or emphasis given was satisfactory except for human engineering and industrial psychology. Since these two courses were not sufficiently defined, the quantitative results were not considered valid, although qualitatively the results may be considered informative.

Evaluation by Graduates

The opinions of graduates of the University of Florida were solicited concerning the education they had received there. Questionnaires were mailed to 175 persons, from whom 94, or 55 per cent, replies were received. The analysis of these replies was given in Chapter V, and the major findings were as follows:

1. Most of the replies were received from a 12-year spread in year of graduation, age, and business experience, as shown:

   (a) Year of graduation: 1946-1957, 92 per cent
   (b) Age, in years: 25-36, 80 per cent
   (c) Business experience: 92.0 per cent

2. The largest number (64) were then or had been engaged in a manufacturing type of industry; 11, 10, and 19 were then or had been engaged in public utilities, marketing and distribution, and government, respectively, the latter including 10 in the Armed Services.

3. The type of work in which they were then or had been engaged was divided into two categories--technical and administrative. Technical work was checked 132 times, and administrative work 66 times. Under the technical category production work received the most checks (35) with the least number (8) in maintenance and repair work. In the administrative category there were 35 checks for supervisory duties, and 17 for management.

4. In evaluating the time or emphasis spent on technical subjects in the curriculum 70 per cent or more indicated that the time spent on the basic sciences--mathematics, chemistry and physics--was satisfactory. Not one person suggested that less time be spent on mathematics, but 30 per cent indicated that more attention should be given to it.

5. More than two-thirds of the replies indicated that the time given to basic engineering subjects was satisfactory, with three exceptions--electrical engineering, manufacturing operations and processes, and laboratory and shop experiences, for which 38, 65, and 54 per cent, respectively of the replies recommended more attention.

6. More than 50 per cent of the replies indicated that the time spent on industrial engineering was satisfactory, except for production planning and control, materials handling, and quality control, in which cases 47 per cent or more thought that more time should be given; in addition 43 per cent indicated that more time should be given to engineering economy. (Operations research is not included here for the reasons given in Chapter V.)

7. The time given to economics, accounting, and miscellaneous elective subjects was considered satisfactory by 57 per cent or more of the replies.

8. Under general education 56 per cent or more of the replies expressed satisfaction with the time given except for English; here 63 per cent indicated that more attention should be given. General education as listed included English, humanities, social studies, general psychology, foreign languages, and, simply for convenience, military and physical education.

9. The value of general education to the individual was rated in three general areas: (a) in relation to his work, (b) in relation to society in his capacity as a citizen, and (c) in relation to his personal life. Under (a) about one-half thought it was of great value, and about one-half thought it was of some value. Under (b) it was also about one-half and one-half for great value and some value; however, under (c) 40 per cent considered it of great value, and 45 per cent of some value.

10. In regard to the relative value of teacher influence compared with subject matter in later life, 51 per cent of the graduates indicated that subject matter was more important in engineering courses, while in nonengineering courses,

37 per cent indicated that teacher influence was more important, with 35 per cent undecided.

Comparison of Curricula

Comparisons were made of the accredited industrial engineering curricula of seven Southern institutions. These comparisons yielded the following findings:

1. It was difficult to make comparisons of specific courses in the various curricula, because of differences in descriptions of the subject matter covered.

2. At Louisiana State University industrial engineering is an option in the mechanical engineering curriculum; in the other institutions industrial engineering has its own separate curriculum.

3. The time spent on general education including electives varied from a minimum of 21 semester credit hours for the Agricultural and Mechanical College of Texas to 42 hours for North Carolina State College.

4. The time allotted to basic science varied from 32 credit hours for the University of Florida to 42 for Georgia Institute of Technology.

5. In basic engineering subjects there was considerable variation in both the subjects required, and the time allotted to each subject. Of the 17 subjects listed, only 7 were common to all the curricula. The total credit hours under this classification ranged from 59 to 88.

6. Among the industrial engineering courses (including required nonengineering technical courses) not one course was common to all seven curricula, but eight courses were included in five or more. The total credit hours for this category varied from 20 to 52, including electives.

7. The credit given to military education varied from 4-8 hours, and this course was required in all seven institutions. Physical education was required in five of the institutions, and the credit allowed varied from 0 to 4 hours. Thus, the total credit hours allowed for both these nonacademic activities ranged from 4 to 12.

8. In summary, the credit hours allowed for the four major subdivisions of the curricula as listed in this study were as follows, in per cents:

Item	Maximum	Minimum	Average
General Education	27	14	19
Basic Science & Eng.	59	39	49
Industrial Eng.	35	13	27
Mil. & Phys. Educ.	8	2	5

Conclusions

The following conclusions were drawn from the data presented in this study:

1. Although the majority of the industrial engineers were engaged in technical work in manufacturing industries, a large number had risen to supervisory and management positions, indicating that the education of the industrial engineer was generally satisfactory.

2. More emphasis should be placed on human relations since the efforts of many people must be coordinated for the successful operation of a modern, complex business organization. This includes the ability to get work done by and through other people.

3. Both employers and graduates appreciated to a considerable degree the value of general education to the engineer in his professional work (including advancement in position), in his relation to our economic system, and in understanding civic and political affairs. To the graduate, general education was also valuable in his personal life.

4. In the field of general education both employers and graduates agreed that the study of English should be given more attention.

5. The technical education of the industrial engineer was in general satisfactory. Although a large number of graduates indicated that more time should be given to three specific subjects, it was possible in some instances that these recommendations were made because of special conditions of employment. (This sentence applies only to graduates of the University of Florida.)

6. In the engineering courses, engineers rated subject matter of a course of greater value than the personality or influence of the instructor, which was to be expected in a highly technical professional field. (This conclusion applies only to graduates of the University of Florida.)

7. There was considerable variation among the seven curricula for industrial engineering. The variation was most apparent in general education and in industrial engineering courses. However, the wide range of elective credit hours would permit such a varied choice of subjects that this apparent variation would undoubtedly be reduced greatly in the final analysis.

8. Since the military curriculum is set up by the Department of Defense, it appears that there is an unduly large range of credit hours allowed for military education.

9. The comparison of curricula contained in catalogs of various institutions involves both qualitative and quantitative factors which cannot be evaluated with exactness, and therefore, great care should be exercised in drawing conclusions from such comparisons. This inexactness results mainly from variations in course titles, indefinite course descriptions, and the variety of selections that can be made from the elective courses.

Recommendations

The recommendations made in this section are made with the understanding of the limitations of this study, and only where they are supported by the findings. It is realized that continued changes in a curriculum are undesirable; those that are made should be for the purpose of improving present courses and adding new courses and deleting old ones as may appear desirable in order to keep abreast of the rapid developments in our modern society in both the human and material fields.

The following recommendations are made:

General Recommendations for Industrial Engineering Curricula

1. No radical changes should be made in the technical areas of the industrial engineering curriculum.
2. In the area of human relations further investigation should be made to devise methods by which industrial engineers could be prepared better not only for getting along with people but also in the art of leadership.
3. Further investigation should be made to determine more definitely the opinions of employers concerning the relative importance in the industrial engineering curriculum of training in the financial aspects of industry.
4. The proper use of English should be stressed during the entire time the student is in college. Continuous emphasis should be placed on the authority of the engineering instructor (where this exists) to recommend additional study of English for any student deficient therein. This authority should be granted where it does not exist.

5. Engineering students should be advised of the opinions of industrial organizations in regard to the importance of general education (especially English) in both their professional work and personal advancement.

Specific Recommendations for the Industrial Engineering Curriculum at the University of Florida

1. The courses required for industrial engineers in electrical engineering, and manufacturing operations and processes should be reviewed for adequacy and modernity.
2. The industrial engineering courses in production planning and control, materials handling, quality control and engineering economy should be reviewed for adequacy and modernity.

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APPENDIX A

QUESTIONNAIRE TO EMPLOYERS

Captain Ralph C. Kephart U.S.N.(Ret)
1004 SW 11th St.
Gainesville, Fla.

Attention: PERSONNEL DIRECTOR

Dear Sir:

The enclosed questionnaire has been prepared for the purpose of obtaining the opinions of employers of engineers as to the content of a university (or college) curriculum for Industrial Engineers. This information is needed for a research survey I am conducting in work for a doctoral degree.

It is felt that changing conditions in industry and society should be reflected in current engineering curricula in order that students may receive the most desirable education in the time available. It should be noted that the questionnaire covers both technical and non-technical areas of study.

I realize, of course, that you are called on frequently for information for various kinds of surveys; however, your cooperation in answering and returning the questionnaire in the enclosed envelope will be greatly appreciated. Your reply will be kept confidential; or if you so desire, you may return it unsigned. In either case, a reply is greatly desired.

A summary of the results will be sent to you, if you so indicate in the place provided.

Sincerely yours,

RCKephart

Ralph C. Kephart

QUESTIONNAIRE ON
INDUSTRIAL ENGINEERING CURRICULUM

A. Type of Industry

1. Manufacturing ____________________

   Type or product . . . .

2. Transportation ____________________

   Type. . . . .

3. Public Utility ____________________

   Type. . . . .

4. Communications ______________

   Type . . . .

5. Services ____________________

   Type . . . .

6. Marketing ___________________

   Type . . . .

7. Other ________________________________

B. The present and continuing accumulation of engineering knowledge indicates the need for the allocation of more time to professional studies. On the other hand, increasing complexities of present day living indicates a greater need for general (or non-technical) education. By general education is meant those areas of study indicated by the following:

English (Speaking, Reading and Writing)
Social Studies (History, Government, etc.)
Humanities (Philosophy, Literature, Arts, etc.)
Economics (General)
Psychology (Including Human Relations)
Foreign Languages

As a result, there arises the problem of the distribution of the student's time between professional and general education during the time he is attending college or university (4 - 5 years).

In view of the above, your answers to the following questions are requested:

1. Should more emphasis be placed on general education, at the expense of professional education?

   Yes ______
   No ______
   ? ______

2. To what degree do your engineers show ability to get along with people?

   Good ______
   Fair ______
   Poor ______

QUESTIONNAIRE ON
INDUSTRIAL ENGINEERING CURRICULUM

3. Should more emphasis be placed on the importance of the ability to get along with people?

Yes ________
No ________
? ________

4. To what degree do your engineers show an appreciation of their responsibilities in our economic system, e.g. the effects of engineering advances such as "automation" on labor-management problems?

Good ________
Fair ________
Poor ________

5. What is your opinion as to the importance of general education as indicated above, to an engineer:

	Essential	Desirable	No Opinion
a. in his professional work			
b. in understanding civil and political affairs--local, national and international			

6. Does your company's experience indicate that general education affects the advancement of an engineer, assuming required professional ability?

Greatly ________
Considerably ________
Slightly ________

7. Specifically, give your opinion in regard to the engineer's training in English:

	Good	Fair	Poor
a. Ordinary conversation			
b. Public speaking (small groups).			
c. Spelling.			
d. Reading (speed and comprehension)			
e. Writing (letters and memoranda)			
f. Report Writing.			

QUESTIONNAIRE ON
INDUSTRIAL ENGINEERING CURRICULUM

C. Based on your company's experience in evaluating the technical qualifications of Industrial Engineers in your employ, what is your opinion as to the relative time or emphasis which should be given to the various studies as listed in the sample Industrial Engineering curriculum given below?

Please check as many as practicable (in the time you have available) using the following code:

M -- More time or emphasis should be given

S -- Satisfactory time and emphasis were given

L -- Less time or emphasis should be given

1. BASIC SCIENCES

M	S	L

   a. Mathematics
   b. Chemistry
   c. Physics

2. BASIC ENGINEERING SUBJECTS, such as:

M	S	L

   a. Engineering Drawing
   b. Descriptive Geometry
   c. Principles of Electrical Engineering
   d. Thermodynamics
   e. Kinematics (Mechanisms)
   f. Engineering Mechanics (Statics & Dynamics)
   g. Strength of Materials
   h. Manufacturing Operations and Processes

3. INDUSTRIAL ENGINEERING SUBJECTS

	M	S	L
a. Engineering Economy.			
b. Human Engineering (In Design and Operation). .			
c. Methods, Time and Motion Study			
d. Production Control			
e. Plant Location, and Layout			
f. Industrial Organization.			
g. Materials Handling			
h. Specifications, Contracts, Ethics.			
i. Accident Prevention (Safety)			
j. Job Analysis and Evaluation.			
k. Quality Control (Including Statistical). . . .			

QUESTIONNAIRE ON
INDUSTRIAL ENGINEERING CURRICULUM

4. MISCELLANEOUS SUBJECTS	M	S	L
a. Economics			
b. Accounting (Elementary & Cost).			
c. Industrial Psychology			
d. Industrial Surveys and Reports.			
e. Personnel Management.			
f. Industrial Relations.			

D. General Remarks: ____

____

____

____

____

E. I (do) (do not) desire a summary of the results.

Name: ______________________________

Address: ____________________________

____

____

APPENDIX B

QUESTIONNAIRE TO GRADUATES

Captain Ralph C. Kephart U.S.N.(Ret)
1004 SW 11th St.
Gainesville, Fla.

Dear Sir:

The enclosed questionnaire has been prepared for the purpose of obtaining your opinions of a curriculum for Industrial Engineers. This information is needed for the preparation of a doctoral dissertation on the subject.

Since Industrial Engineers engage in many different types of work after graduation, there arises the problem of selecting not only the subject matter of the curriculum, but also the relative time or emphasis to be given to the subjects selected for the course of study.

The above refers primarily to technical subjects. In addition there are non-technical aspects of your education which are covered under the heading of "General Education". Your opinion in this field is considered of equal importance to that in the technical area.

Since this questionnaire is being sent to a limited, selected group of graduates of the University of Florida, your cooperation in answering and returning this questionnaire in the enclosed envelope will be greatly appreciated. Your reply will be kept confidential; or you may return the questionnaire without signing it if you so desire; in either case, a reply is greatly desired.

A summary of the results of the study will be sent to you, if you so indicate in the place provided.

Sincerely yours,

RCKephart

Ralph C. Kephart

QUESTIONNAIRE ON INDUSTRIAL ENGINEERING CURRICULUM

A. (1) Year of your graduation . . . . . . ________ Degree ______

(2) Years in active business. . . . . . ________

(3) Age . . . . ________

B. Type of Industry(ies) in which you have been engaged:

1. Manufacturing ________
2. Transportation ________
3. Public Utilities ________
4. Distribution/Marketing ______
5. Communications ______
6. Government ______
7. Other ____________________

C. Type(s) of your work (Indicate briefly by position title):

1. TECHNICAL ENGINEERING

Title

Production ______________________________

Methods Analysis ______________________________

Sales Engineering ______________________________

Maintenance/Repair ______________________________

Design ______________________________

Consulting Services ______________________________

Other (Specify) ______________________________

2. ADMINISTRATIVE

Title

Supervision ______________________________

Management ______________________________

Personnel ______________________________

Other (Specify) ______________________________

QUESTIONNAIRE ON
INDUSTRIAL ENGINEERING CURRICULUM

D. From your experience, please give your opinion of your college education in regard to the relative time or emphasis which should be given to the various areas of study in the sample curriculum outlined below, by checking the individual subjects under each heading, using the following code:

M -- More time or emphasis should be given

S -- Satisfactory time or emphasis was given

L -- Less time or emphasis should be given

1. BASIC SCIENCES	M	S	L
a. Mathematics			
b. Chemistry			
c. Physics			
d. Laboratory (Chemistry, Physics)			

2. BASIC ENGINEERING SUBJECTS	M	S	L
a. Engineering Drawing			
b. Descriptive Geometry.			
c. Principles of Electrical Engineering.			
d. Thermodynamics.			
e. Kinematics (Mechanisms)			
f. Engineering Mechanics (Statics & Dynamics). .			
g. Strength of Materials			
h. Manufacturing Operations and Processes. . . .			
i. Laboratory and Shop Experience.			

3. INDUSTRIAL ENGINEERING SUBJECTS	M	S	L
a. Engineering Economy			
b. Human Engineering (In Design and Operation) .			
c. Methods, Time and Motion Study.			
d. Production Planning and Control			
e. Plant Location and Layout			
f. Materials Handling.			

	M	S	L
g. Operations Research			
h. Industrial Organization			
i. Specifications, Contracts, Ethics			
j. Accident Prevention (Safety).			
k. Job Analysis and Evaluation			
l. Quality Control			
m. Other (Specify)			

4. MISCELLANEOUS	M	S	L
a. Economics			
b. Accounting (Elementary & Cost).			
c. Industrial Psychology			
d. Industrial Surveys and Reports.			
e. Personnel Management.			
f. Industrial Relations.			

5. GENERAL EDUCATION

(Under this heading are listed non-technical subjects which contribute primarily to one's effectiveness as a citizen and to his own personal development as distinct from professional subjects listed above)

	M	S	L
a. English (Reading, Writing, Speaking).			
b. Social Studies (History, Government, etc.). .			
c. Humanities (Philosophy, Literature, etc.) . .			
d. Psychology (General).			
e. Foreign Languages			
f. Military Education.			
g. Physical Education.			

QUESTIONNAIRE ON
INDUSTRIAL ENGINEERING CURRICULUM

E. In regard to "General Education" (D-5 above) please indicate your opinion of the value of this area of study by checking the appropriate columns opposite the statements listed below:

	Great Value	Some Value	Little Value
1. In the work in which you are engaged . .			
2. In understanding the relation of the work of the engineer to our present economic system.			
3. In understanding the effects of continuing technological advances (such as automation) on our social and economic system.			
4. In understanding civic and political affairs--local, national and international			
5. In relation to your own personal and family affairs and problems.			
6. Satisfying use of leisure time			

7. Remarks ____

____

____

F. Which of the following factors have had the greatest value in your education:

	Eng'g. Subjects	Non-Eng'g. Subjects
1. Influence of the teacher (personality, etc.)		
2. Subject matter of the course		

(Note--if undecided, leave blank)

G. I (do) (do not) desire a summary of the results.

Name: ______________________________

Address: ____________________________

____

____

APPENDIX C

INDUSTRIAL ENGINEERING CURRICULA OF SEVEN INSTITUTIONS OF HIGHER LEARNING

University of Alabama

Industrial Engineering Curriculum

In Semester Hours

Freshman Year

General Chemistry CH 1	4
Engineering Drawing I DR 31	2
English Composition EH 1	3
College Algebra MA 11	3
Trigonometry MA 15	3
Basic Military MIL 1	1
General Chemistry CH 2	4
Engineering Drawing II DR 32	2
English Composition EH 2	3
Analytic Geometry MA 25	3
Basic Military MIL 2	1
Technical Physics PH 5	5
	34

Sophomore Year

Principles of Economics EC 41	3
Manufacturing Processes IE 49	4
Engineering Analysis GES 22	1
Calculus MA 49	5
Technical Physics PH 6	5
Descriptive Geometry DR 33	2
Economic Problems and Policies EC 42	3
English Classics EH 45	3
Industrial Organization IE 51	3
Calculus MA 51	3
Statics MH 81	3
Basic Military 3, 4	2
	37

Junior Year

Industrial Accounting and Costs AC 141, 142	6
Electrical Machinery EE 93	3
Electrical Engineering Lab. EE 94	1
Technical English EH 184	2

University of Alabama
Junior Year--Continued

Analysis of Engineering Data IE 55	3
Mechanisms ME 2	2
Dynamics MH 82	3
Methods and Measurements IE 99	5
Industrial Application of Statistics IE 190	2
Strength of Materials MH 93	3
Fluid Mechanics MH 109	3
Electives	6
	39

Senior Year

Humanities HU	3
Production Control IE 107	3
Thermodynamics ME 102	3
Machine Design ME 112	2
Engineering Metallurgy MTE 91	3
Industrial Structures CE 109	3
Humanities HU	3
Industrial Engineering Economics IE 102	2
Factory Planning IE 115	3
Seminar IE 192	1
Electives IE	4
Public Speaking SH 4	2
Electives	6
	38

University of Florida

Industrial Engineering Curriculum

In Semester Hours

Freshman Year

Man and the Social World C11 - 12	8
Reading, Speaking and Writing C31 - 32	8
General Chemistry CY 217 - 18	8
Basic Mathematics MS 105 - 6	8
Engineering Drawing - Descriptive Geometry EGR 181-2	6
Military Science	2
Physical Fitness	0
	40

Sophomore Year

The Humanities C51 - 52	8
General Physics - Physics Laboratory, PS 205-6-7-8	8
Calculus MS 353-4	8
Mechanics and Kinematics EGR 282	3
Engineering Mechanics - Statics EM 365	3
Introduction to Industrial Engineering IG 201	2
Military Science	2
Physical Fitness	0
	34

Junior Year

Elementary Accounting ATG 211-12	6
Basic Economics ES 201, 202	6
Elements of Electrical Engineering EL 341-2	6
Dynamo Laboratory EL 349-50	2
Engineering Mechanics - Dynamics EM 366	3
Strength of Materials EM 367	3
Job Analysis and Evaluation IG 371	2
Time and Motion Study IG 372	3
Manufacturing Operations ML 489-90	6
	37

Senior Year

Thermodynamics ML 385	3
Engineering Economy IG 460	3
Specifications, Engineering Relations and Industrial Safety	3
Human Engineering IG 472	2

University of Florida
Senior Year--Continued

Plant Locations, Selection and Layout IG 469	4
Plant Operation and Controls IG 470	4
Industrial Engineering Seminar IG 479	1
Cost Accounting ATG 313	3
Electives	12
	35

Georgia Institute of Technology

Industrial Engineering Curriculum

In Quarter Hours

Freshman Year

Inorganic Chemistry CH 101-2-3	12
Engineering Drawing DR 101-2-9	6
Composition and Rhetoric 101-2-3	9
Algebra MATH 101	5
Trigonometry MATH 102	5
Analytical Geometry MATH 103	5
Modern Language or Social Science ML 111-12-13	9
Physical Training 101-2-3	3
Military Science and Tactics	6
Orientation GEN 101	0
	60

Sophomore Year

Applied Mechanics MECH 301	2
Principles of Economics EC 201-2	6
Survey of the Humanities ENG 201-2-3	9
Calculus MATH 201-2-3	15
Manufacturing Processes MFG Proc. 201, 5, 6	3
Physics PHYS 207-8-9	18
Military Science and Tactics	6
Physical Training	3
	62

Junior Year

Applied Electricity EE 316-7	6
Accounting & Cost Accounting IM 336-7	7
Applied Mechanics MECH 302	2
Mechanics of Materials MECH 331-2	5
Organization for Production IE 304	3
Evaluation of Engr. Data IE 339	3
Motion and Time Study IE 417	5
Thermodynamics ME 322-2	6
Fluid Mechanics CE 324	4
Introduction to Higher Algebra MATH 309	3
Metallurgy CH.E. 325	3
Technical Writing ENG 320	3
Electives	9
	59

Georgia Institute of Technology

Senior Year

Materials Laboratory ME 353	1
Public Speaking ENG 315	3
Machine Design ME 367	5
Industrial Psychology PSY 401	3
Industrial Accident Control SE 401	3
Production Control IE 306	3
Quality Control IE 439	3
Seminar IE 411-2	2
Engineering Economy IE 425	3
Industrial Surveys & Reports IE 410	2
Cost & Production Estimating IE 420	3
Materials Handling IE 424	3
Factory and Process Design IE 447	4
Job Evaluation & Wage Incentives IE 422	3
Legal & Ethical Phases of Engineering IE 490	3
Electives	9
	53

Louisiana State University

Industrial Engineering Option in Mechanical Engineering

In Semester Hours

Freshman Year

Chemistry 1, 2, 3, 12	9
English 1b, 1c, or 1c plus English course numbered above 50	6
History, Geography or Sociology 1 - 2	6
Mathematics 1a - 2, 53 or 1b, 2 - 53	9
Engineering Drawing 1	2B
Books & Libraries 1	1
Military or Air Science	4
	37

Sophomore Year

Engineering Drawing 1	2
Descriptive Geometry 54	2
Calculus MATH 63-64	10
Machine Shop ME 72	1
Physics 61, 63-62, 64	10
Engineering Mechanics (Statics) 52	3
Military or Air Science, Band	4
Electives (Humanistic and Social)	6
	38

Junior Year

Engineering Mechanics (Dynamics) 101	3
Thermodynamics EM 115	3
Strength of Materials EM 135, 151	5
Fluid Mechanics HYD 162	3
Industrial Organization and Management IE 61	3
Electrical Engineering 53, 73-54, 74	8
Manufacturing Processes ME 77	2
Machine Design ME 110	2
Applied Thermodynamics ME 164	3
Electives (Humanistic and Social)	6
	38

Senior Year

Hydraulic Laboratory 124	1
Engineering Economy ME 130	2

Louisiana State University
Senior Year--Continued

Machine Design ME 111, 112	6
Metallurgy ME 113, 114	4
Safety Engineering ME 120	3
Electives (Technical)	12
Electives	9
	37

North Carolina State College

Industrial Engineering Curriculum

In Semester Hours

Freshman Year

General Inorganic Chemistry and Qualitative Analysis CH 101-3	8
Composition ENG 111, 112	6
Introduction to Engineering ENG 100	1
The Modern Western World HI 205	3
First Year Mathematics for Engineers MA 101, 102	9
Engineering Graphics ME 101, 102	4
Military or Air Science MS 101, 102 or 121, 122	4
Physical Education PE 101, 102	2
	37

Sophomore Year

Industrial Organization and Management IE 206	3
Machine Tools and Metal Forming IE 217, 218	2
Calculus MA 201, 202	8
General Physics PY 201, 202	10
Introduction to Psychology PSY 200	3
Humanities	6
Military or Air Science MS 201, 202, or AS 221, 222	4
Physical Education 201, 202	2
	38

Junior Year

Principles of Accounting EC 401	3
Mechanics A, B (Statics, Dynamics) EM 341, 342	4
Scientific Writing ENG 321	3
Engineering Economy IE 301	2
Manufacturing Process IE 328	3
Motion and Time Study IE 332	4
Plant Layout and Materials Handling IE 343	4
Engineering Thermodynamics I ME 301	3
Introduction to Statistics for Engineers ST 361	2
Contemporary Civilization SS 301-302	6
Military, Air Science or Electives	6
	40

North Carolina State College

Senior Year

Elements of Electrical Engineering EE 320	4
Strength of Materials A and Fluid Mechanics EM 343, 430	4
Production Control IE 408	3
Job Evaluation and Wage Administration IE 430	3
Quality Control IE 443	3
Seminar IE 451, 452	2
Group I Elective and Technical Elective	6
Contemporary Issues I and Elective in Humanities SS491	6
Military, Air Science or Electives	6
	37

University of Tennessee

Industrial Engineering Curriculum

In Quarter Hours

Freshman Year

Mathematics 121	15
English 111-2-3	9
Chemistry	12
Engineering Drawing 141-2-3	12
Elementary Surveying CE 111	2
Machine Shop ME 121	2
Engineering Problems 123	2
Military Science 111-2-3	3
Physical Education 111-2-3	1
	58

Sophomore Year

Mathematics 221-2-3	15
English 211-2-3, or Speech 231	9
Physics 261-2-3	12
Introductory Industrial Engineering 221-2-3	9
Economics 211-2	6
Mechanics (Statics) 213	3
Military Science 211-2-3	3
Physical Education 211-2-3	1
	58

Junior Year

Electrical Engineering 311-2-3	9
Mechanics (Kinetics) 311	3
Mechanics (Strength of Materials) 312	3
Mechanics (Materials of Engineering) 321	3
Motion and Time Study IE 321	3
Wage Incentive Methods IE 425	3
Quality Control IE 441	3
Statistics 345	3
Chemical Engineering 311-2	6
Economics of the Process Industries IE 451	3
Accounting 355-6-7	9
Humanistic Social Elective	3
Psychology 345 or Sociology 461	3
	54

University of Tennessee

Senior Year

Production Analysis IE 411	3
Plant Layout IE 412	3
Design of Manufacturing Enterprise IE 413	4
Work Measurement Techniques IE 421	3
Thesis IE 401	3
Seminar IE 431-2-3	3
Production Control IM 431	3
Labor Economics 341	3
Humanistic Social Elective	6
Applied Engineering Thermodynamics ME 311-2	6
Contracts and Specifications CE 423	3
Fluid Mechanics HYD 311 or Metallurgy 481	3
Technical Electives	9
	52

Agricultural and Mechanical College of Texas

Industrial Engineering Curriculum

In Semester Hours

Freshman Year

General Chemistry CY 101, 102	8
Engineering Drawing 105	2
Composition and Rhetoric EN 103, 104	6
History of the United States, 105, 106	6
Algebra MA 102	3
Plane Trigonometry MA 103	3
Descriptive Geometry ED 106	2
Analytics MA 104	3
Engineering Problems ME 108	3
Military or Air Science	2
Physical Education 101, 102	R
	38

Sophomore Year

Principles of Economics EC 205	3
Composition and Literature EN 203	2
American National Government GOV 306	3
Calculus MA 209, 210	6
Welding and Foundry ME 201	1
Machine Shop ME 309	1
General Physics PHS 203, 204	10
Physical Education 201, 202	R
Business Law BA 305	3
Introduction to Industrial Engineering IE 202	2
Calculus MA 210	
Welding and Foundry ME 202	1
Engineering Mechanics ME 212	3
Machine Shop ME 310	1
Military or Air Science	2
	38

Junior Year

Survey of Accounting Principles BA 409	3
Mechanics of Materials CE 305	3
Electrical Circuits EE 307	4
Production Engineering IE 302	2
Engineering Mechanics ME 313	3
Cost Accounting Survey BA 430	3

Agricultural and Mechanical College of Texas
Junior Year--Continued

Strength of Materials Laboratory CE 315	1
Electrical Machinery EE 308	4
Motion and Time Study IE 404	3
Thermodynamics ME 323	4
Electives	6
	36

Senior Year

Public Speaking EN 401	1
Wage and Salary Control IE 411	3
Statistical Control of Quality IE 414	3
Production Control IE 415	2
Tool Engineering IE 451	2
Kinematic Drawing ME 337	1
Physical Metallurgy ME 440	3
Writing for Professional Men EN 301	3
Seminar IE 408	1
Labor and Industry IE 412	3
Factory Layout IE 416	3
Tool Design Laboratory IE 452	1
Approved Electives	5
Electives	6
	37

BIOGRAPHICAL SKETCH

Ralph Claude Kephart was born in Jamison, Pennsylvania on March 7, 1900. He was graduated from the United States Naval Academy in 1922 and commissioned Ensign in the United States Navy. Later he was awarded the degree of Bachelor of Science. After several years of varied naval duties, he did graduate study in engineering and received the degree of Master of Science from Columbia University in 1930. Subsequent naval service included shipboard duties in engineering, navigation, and gunnery, and duty ashore in the Navy Department, Washington, D. C., and at the New York Navy Yard. During World War II he was senior engineering officer on the staff of the Commander of Destroyers,Atlantic Fleet for three years, after which he was transferred to duty as Senior Repair Officer, Puget Sound Navy Yard, Washington. Later he was in command of the Repair Department, United States Naval Base, San Diego, California. He retired from the United States Navy with the rank of Captain in 1947. Subsequently he joined the Kellex Corporation in New York City where he was engaged in the design of atomic energy plants. He pursued graduate study at the University of Florida from 1949 until 1951 at which time he was recalled to active Naval duty

BIOGRAPHICAL SKETCH--Continued

for two years in Washington, D. C. In 1953 he joined the staff of the Industrial Engineering Department, College of Engineering, University of Florida, for research and teaching. At present he is on the staff of the Engineering Graphics Department, College of Engineering, University of Florida. He is a member of Phi Delta Kappa, the American Society for Engineering Education, and the American Society of Naval Engineers.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Education and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Education.

February 1, 1957

J. B. White

Dean, College of Education

Dean, Graduate School

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